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THE BLUEBERRY LEAF-BEETLE AND SOME OF ITS RELATIVES.

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BULLETIN 319

THE BLUEBERRY LEAF-BEETLE AND SOME OF ITS RELATIVES.

Part One. Systematic. The New England Species of Galerucella.[1]

By H. C. Fall.

Some years ago, in the course of a correspondence with Dr. William Colcord Woods concerning his then recently described new species of Haltica, he mentioned having been at work for several summers on the life histories of some of the Maine species of Galerucella, and his conclusions from the immature stages that we have several undescribed species, which are at present included under the names *decora* and *cavicollis*. Doctor Woods suggested at that time that, if interested, I should draw up descriptions of the adults, as he preferred that that part of the work be done by a systematist. The matter, having been left in abeyance for some time, has this summer (1923) been taken up again, and Doctor Woods has sent me bred material of the several species. A study of these supplemented by additional adults taken in the field by myself, satisfies me that we have to do with several closely allied but distinct species, and, that with some care these are definable from the beetles themselves, regardless of their food plants or larval characteristics; the latter however, constituting confirmatory evidence of the greatest value.

The last monographic treatment of the North American *Galerucini* was that by Dr. Geo. H. Horn some thirty years ago.[2] In this paper eleven species of Galerucella are recognized, of which at least nine (if LeConte's interpretation of *tuberculata* is correct) certainly occur in New England. We now know, chiefly from breeding from the egg, and the systematic study of all stages of development by Doctor Woods, that the *cavicollis* and *decora* of Horn's paper and of collections generally are compos-

[1]Papers from the Maine Agricultural Experiment Station: Entomology No. 115.

[2]Trans. Amer. Ent. Soc. XX, April, 1893.

ite, and that there are at least five more species in our New England fauna than have been recognized by authors.

Although the present investigation has to do chiefly with the species allied to *cavicollis* and *decora,* it is thought best to include all the New England species in the following table, the more so because my study convinces me that certain of the LeConteau names now held in synonymy must be restored.

Types of the new species described in the following pages are in the writer's collection. Paratypes will be deposited in the collections of the Maine Agricultural Experiment Station at Orono, and the National Museum.

KEY TO THE NEW ENGLAND SPECIES OF GALERUCELLA.

1. Front coxae narrowly but distinctly separated, middle coxae separated by a distance subequal to one-half the coxal width; prothorax polished and nearly impunctate except in the depressions.....*nymphaeae*
   Front coxae contiguous, middle coxae closely approximate but rarely in actual contact.....2
2. Elytra testaceous with vittate markings.....3
   Elytra not vittate.....8
3. Elytra with a broad piceous nearly entire vitta from the humeral callus, and a short narrow one from the middle of the base; punctuation of elytra fine and dense..*xanthomelaena*
   Elytra testaceous each with three or four narrow piceous vittae; punctuation coarser.....4
4. Body rather broadly oval and strongly convex, size generally larger; elytra very coarsely punctate, each with three narrow brownish or piceous discal vittae, which are subject to partial or total obliteration.....5
   Body more depressed, size generally smaller; upper surface always with decumbent pubescence, the erect hairs when present very sparse and extremely short, visible only in profile under close examination.....6
5. Upper surface virtually glabrous; prothorax smoother and more shining, the punctuation sparser and unevenly distributed.....*cribrata*
   Upper surface conspicuously pubescent with a mixture of erect and subrecumbent hairs; prothorax densely and rugosely punctate.....*americana*
6. Form as a rule broader and more dilated behind; elytra coarsely and densely punctate, each with three narrow blackish subentire discal vittae.....*conferta*
   Form narrower and more oblong; elytra less coarsely punctate, each with sutural and three discal vittae.....7

7. First discal vitta joining the sutural at or behind the middle ..... *notulata*
   First discal vitta very short, basal..... *notata*
8. Side margins of elytra thickened or with a convexity between the declivity and the epipleural edge (most noticeable toward the base) ; color red, antennae black, pubescence sparse.....9
   Side margins of elytra without or with but feeble indication of convexity (most noticeable in *kalmiae*).....10
9. Prothorax and elytra densely punctate and dull, body beneath and legs concolorous with the upper surface... *rufosanguinea*
   Prothorax coarsely less closely punctate, shining; tarsi and frequently the metasternum blackish..... *cavicollis*
10. Prothorax coarsely discretely punctate and somewhat shining, nearly as in *cavicollis;* form rather broad, color clear red, antennae pale at base..... *kalmiae*
    Prothorax densely confusedly or rugosely punctate and dull 11
11. Size large (about 5.5 mm.) ; color dull reddish brown, antennae black, tibiae and tarsi black or piceous (typically) varying to nearly concolorous; last ventral of female with a small narrow incisure at apex, from which a well defined groove extends forward; male with the excavation of the last ventral very large, nearly or quite attaining the base of the segment..... *tuberculata*
    Size smaller (except in occasional very large examples) ; last ventral of female with apex unmodified (except in *spiraeae* most females of which have a similar but less developed structure) ; excavation of last ventral in male always shorter than the segment.....12
12. Antennae wholly or in great part, and legs entirely, pale; form rather short and stout; color dull yellow, varying to reddish or brownish testaceous..... *vaccinii*
    Antennae in great part fuscous or blackish; form narrower and more oblong.....13
13. Body beneath not black, the abdomen sometimes a little darker, head at most with a small dusky occipital spot *(spiraeae)*.....14
    Body beneath in great part black, the abdominal apex paler; head posteriorly broadly blackish.....16
14. Color generally luteous or brownish yellow, thorax feebly to distinctly trimaculate; last ventral of female usually with a small narrow incisure at apex, from which there may or may not be an impressed line extending forward..... *spiraeae*
    Color dark reddish brown; thorax without or with only vague and diffuse traces of discal spots; last ventral of female without apical incisure.....15

15. Prothorax a little more roughly punctured, especially at the middle of the disk; second antennal joint relatively a little longer; claws as a rule more widely bifid ..... *alni*

Prothorax less roughly sculptured, the middle of the disk smoother than in *alni,* but nearly as in *decora;* second antennal joint relatively shorter; claws more narrowly bifid..... *perplexa*

16. Prothorax smoother than in the allied species (except possibly *perplexa*), distinctly trimaculate; color generally a dull luteous; typically more densely pubescent than in any of the preceding species..... *decora*

It will be observed in the above table that having removed *nymphaeae* because of its more distinctly separated front and middle coxae, the remaining species divide into two series, one with and the other without vittiform elytral markings. In this connection it will be of interest to state that these two groups are phytogenetically distinct not alone in the color character mentioned, but also in the form of the aedeagus of the male; the vittate species having the copulatory spicule gradually symmetrically acuminate, while in the non-vittate group this organ is less pointed at tip, and asymmetric owing to a short sinus on one side just before the apex. Classified on this basis, *nymphaeae* belongs with the vittate species; indeed we may consider the pale elytral margin as a sort of lateral vitta, and specimens do occasionally occur with a suggestion of a pale discal stripe.

It will be further seen from the table that two subgroups of the non-vittate series are indicated, depending on the structure of the elytral margin. This is the character alluded to by LeConte in his paper of 1865,[3] where he says (of *cavicollis, rufosanguinea* and *haematica*)—"Marginal sulcus distant from the margin, which is thickened." The marginal thickening or convexity is best appreciated when viewed horizontally. It is usually feebly indicated in *kalmiae* of the second section, which, in case of doubt may be separated from the preceding species by the antennae not entirely black.

Of one species of each section—*cavicollis* and *decora*—the description following is made relatively full, for comparative purposes. The general structure being so nearly uniform through-

[3]On the species of *Galeruca* and Allied Genera inhabiting North America. Proc. Acad. Nat. Sci. Phila. Oct., 1865, p. 214.

out, the remaining descriptions are made rather brief, attention being centered on those characters which are of diagnostic value.

G. nymphaeae L. This is the common Galerucella of the water lilies. The smooth polished thorax—except for the punctate foveae—pale elytral margin and more distinctly separated middle coxae, make it easily recognizable. It is widely distributed in Europe and North America.

G. xanthomelaena Schr. This is the too well known elm leaf beetle of our northeastern states. It occurs abundantly all over Europe, and is gradually spreading westward in the United States.

G. cribrata Lec. I am pretty thoroughly convinced of the necessity of restoring this name of LeContes' to specific standing. Horn supposed the glabrous *cribrata* to be merely denuded specimens of *americana*. He observes that in some examples the thorax is relatively sparsely punctured with smooth intervals, but states that these are always females. As a matter of fact, the smoother thorax and glabrous surface always go together, and in any considerable series of either both sexes are sure to be found.

G. americana Fab. This species should be easily recognized by the stout convex form and conspicuous dual pubescence, there being an abundant intermixture of short erect hairs throughout the surface of the elytra. Partially abraded specimens occur of course, but I have never seen one so completely denuded as to suggest *cribrata,* and were such to occur the dense subrugose punctuation of the thorax in the present species should at once identify it.

G. conferta Lec. In suppressing the present species as a form of his Protean *americana,* Horn was again at fault. *Conferta* is certainly not *americana,* but is on the other hand, extremely close in some of its forms to *sexvittata,* from which I am inclined to believe it will prove distinct when the life histories shall have been worked out. As compared with *sexvittata* it is of somewhat broader form, more dilated posteriorly, and is appreciably more coarsely punctate; quite conspicuously so when typical examples of the two are compared. The unique type of *sexvittata* in the LeConte collection is said to be from Pennsylvania. I have seen no others from Pennsylvania, but have a good series from Florida which seem to agree in all respects with the type. All northern specimens of *sexvittata* that I have seen seem

rather to belong to *conferta,* though some of them exhibit a very puzzling approach to the *sexvittata* form. Here as elsewhere in this difficult genus a thorough exposition of life histories is the necessary desideratum to an exact knowledge of the relationships of the various forms. *Conferta* is a rather common species in Quebec and New England and extends its range westward to Illinois at least, and in Canada to Manitoba and Alberta.

G. notulata Fab.

G. notata Fab. These two species may be readily recognized by the tabular characters—at least so far as New England specimens are concerned. They are widely dispersed over almost the entire country, unless, as seems not unlikely, some of the variations of remote western regions prove to be distinct species.

G. rufosanguinea Say. Of the same size and form as *cavicollis,* but differing notably by the denser punctuation and more pronounced surface opacity. The color is the same sanguineous red, the body beneath and legs throughout nearly concolorous. The last ventral of the male is as in *cavicollis;* that of the female shows no appreciable emargination or impression in any of the specimens at hand. The claws are nearly similar in the sexes.

Rufosanguinea is far more circumscribed in habitat than *cavicollis.* It was described from Pennsylvania and is given in the Western Pennsylvania, District of Columbia and New Jersey Lists, always as occurring on Azalea. Dary does not record it in the Cincinnati list, so it perhaps does not extend its range into the Mississippi Valley. It is known to me from Eastern New York and Doctor Woods has recently taken it in Connecticut—Chagnon records it from numerous localities in Quebec, but the correctness of the determination may be seriously questioned.

G. cavicollis Lec. Rather broadly oval, slightly oblong, moderately convex, a little wider behind. Color a rather dull but clear red, somewhat shining, finely sparsely pubescent. Antennae rather stout, about half the length of the body, black throughout, third joint one-half to two-thirds longer than the second, and a little longer than the fourth. Head entirely red, densely cribrate punctate behind the frontal tubercles. Prothorax small, nearly twice as wide as long, a little narrower in front, sides arcuate, more or less subangulate at middle, front angles prominent, hind angles subrectangular, the base feebly sinuate at middle, obliquely sinuate at sides, disk with a median impression and a broader

deeper excavation each side; punctures coarse and deep, generally well separated but denser in the impressions. Because of these impressions the front marginal region appears somewhat swollen, narrowly at middle, more broadly at the angles. Elytra oblong oval, a little wider behind, one-half longer than wide, margins explanate, humeral angles distinct but rounded; punctures coarse and deep, separated by rather less than their own diameters on the average; pubescence sparse and inconspicuous, each hair arising at the front margin of a puncture, across which it lies, its length being sensibly equal to the diameter of the puncture. Body beneath red, metasternum sometimes piceous, sparsely finely punctate and finely pubescent. Legs red, the tarsi and sometimes the apices of the tibiae fuscous or piceous. Length 4.25 to 5 mm., width 2.2 to 2.8 mm.

Male. Claws more finely bifid at apex, especially of the front feet; last ventral broadly emarginate at apex and with a large and deep subtriangular impression which is smooth and polished at bottom and distinctly recessed anteriorly so as to be acutely margined.

Female. Claws more widely bifid; last ventral not evidently emarginate, at most an extremely minute notch at middle, from which a very fine impressed line extends forward half the length of the segment, both notch and line tending to become obsolete.

A common northern insect, ranging across the country from New England to Alberta. It is recorded from New Jersey and Western Pennsylvania, but does not appear in the Washington or Cincinnati lists. LeConte's type, received from Zimmermann was described as from North Carolina, but according to Crotch, Zimmermann's specimens really came from Massachusetts. The native food plant of *cavicollis* is undoubtedly wild cherry, from which it has on occasion transferred its attention to cultivated cherry, and more rarely to plum and peach.

G. kalmiae n. sp. Extremely similar to *cavicollis,* from which in form, size, general color, lustre and punctuation it is scarcely distinguishable. The convexity of the elytral margin is here, however, quite feeble, and still more nearly disappears in the following species. The antennae in *kalmiae* are always pale at base, becoming dusky or blackish externally, by which it may at once be separated from the preceding species; moreover the legs are entirely red, whereas in *cavicollis* the tarsi and often the

apical parts of the tibiae are more or less piceous. The under body is sometimes darker in tint than the upper surface, but is never truly piceous. The ventral sexual characters in the male are as in *cavicollis;* the last ventral of the female quite simple, as in *rufosanguinea.*

Length 4.5 to 5.7 mm.; width 2.4 to 2.9 mm.

The type is a male from Tyngsboro, Mass., and bears date "1X-15-23."

This species is common on laurel in northern New England; my specimens are from various points in Maine, New Hampshire and Massachusetts and bear dates May 28 to Sept. 19.

G. tuberculata Say. This species is included among the New England Galerucellae on the basis of a series of specimens in the Blanchard collection from the White Mts. of New Hampshire— Other like specimens are in my collection from Lanoraie and Hull, Quebec, (Coll. by Beaulne). These differ from the typical form in their entirely rufous legs and blackish metasternum, but otherwise seem to differ in no respect from Pennsylvania and Maryland specimens, one of which bears the name label *"tuberculata* Say" in the LeConte collection. These latter satisfy Say's description thoroughly well, and agree with specimens before me from Ohio (Liebeck) and Indiana (Blatchley) which are undoubtedly the equivalent of Say's "Missouri" type. The *G. tuberculata* of Horn's Monograph is the pale form of *punctipennis* Mann and has nothing to do with the true *tuberculata* of Say. It is difficult to account for Horn's dictum in this matter if one but reads the original descriptions. In *punctipennis* the occiput and body beneath are black, the thorax yellow trimaculate with black, the elytra black, or in a varietal form dingy yellow. In *tuberculata* the body is reddish brown above and beneath, the head and thorax without spots, the latter more densely punctate, the sexual modifications of the last ventral more pronounced. They occupy moreover entirely different faunal areas. In a lot of Galerucellae sent me for study by Mr. Liebeck, I find examples of *tuberculata* from Franconia, N. H., Toronto, Can., Newport, N. Y.; Stroudsburg and Water Gap, Pa., and Columbiana, Ohio. These show quite conclusively that the color of the tibiae, tarsi, and metasternum may be rufous, blackish, or anything between.

G. vaccinii n. sp. Of somewhat smaller size than any of the allied species, the form rather stout. The color varies from dull

yellow through brownish yellow to reddish brown. The punctuation is denser than in *cavicollis,* the pubescence more plentiful, the surface lustre dull. The body throughout and appendages are nearly or quite concolorous, the prothorax very rarely showing any trace of the dark discal spots. The antennae are typically entirely pale, but in some specimens the outer joints are a little darker. In this and the following species the punctuation of the thorax is less coarse and more crowded than in *cavicollis* and *kalmiae,* the individual punctures not very distinct except near the margins. The elytral punctures are nearly as coarse as in *cavicollis.* The sexual ventral characters are as in *kalmiae.* Length 3.7 to 4.7 mm.; width 2.2 to 2.6 mm. This species occurs not rarely on Vaccinium. My specimens are from Maine (Orono-Woods); New Hampshire (Farmington); Massachusetts (Tyngsboro) and bear dates in May, June and September. The type is a female, bearing label "Tyngsboro, Mass., VI-1-'23."

G. spiraeae n. sp. Closely similar to *vaccinii,* from which the somewhat narrower more oblong form and darker antennae may be depended on to separate it. So far as observed, the very small apical notch of the last ventral segment which occurs in many females, is, when present, a reliable means of distinguishing this species from others most nearly allied. A similar structure, better developed, exists in *G. tuberculata,* but this is a considerably larger species with entirely piceous antennae. The color in *spiraeae* is generally a dull luteous or yellowish brown, deepening, however, to reddish brown in some individuals. The punctuation and pubescence are as in *vaccinii,* but unlike that species, traces of the thoracic spots are here nearly always present, though not quite so constantly and conspicuously so as in *decora.* Length 4 to 4.5 mm.; width 2 to 2.25 mm. I have taken this species in numbers on Spiraea in Maine, New Hampshire, and Massachusetts in both June and September. I have also a good series from Montreal, kindly sent by Mr. Chagnon. The type is a female, collected by the writer at Farmington, New Hampshire.

G. alni n. sp. Form and size nearly as in *decora;* color deep reddish brown to fuscous brown, darker in series than any other of the allied forms, and rather more densely and coarsely punctate than any of the similarly pubescent species *(tuberculata* to *decora).* As in all the species following *vaccinii* the antennae are dusky or blackish, the basal joints in part paler, especially be-

neath. The thorax shows no definite maculation and is rather more distinctly punctate than in the next species *(perplexa)* which it most closely resembles. There is nothing of importance to add to the tabular characters. Length 4.8 to 5.2 mm.

I have not personally collected this species; the series before me, including the type, is from Orono, Maine, and was kindly submitted by Doctor Woods.

G. perplexa n. sp. Extremely similar to the preceding species, from which the student may perhaps with care be able to distinguish it by means of the tabular characters, which at best are not very marked. The most reliable means of distinction seems to be the thoracic sculpture, which in the present species is appreciably finer and smoother, the punctuation obscurely defined, approaching in general appearance that prevailing in *decora.* The slightly shorter third antennal joint and less widely bifid claws are of but slight importance and probably not reliable in individual instances, but seem to have a small contributory value in the series before me. This species—if such it is—has caused me more perplexity than any other. The beetles themselves are at once and with certainty separable from *decora,* but are so similar to *alni* as to be distinguished only with the greatest care: on the other hand, in the immature stages, so Doctor Woods writes, the present species is definitely separable from *alni* but is virtually identical with *decora,* and lives on the same food plant (willow), although so far as observed it does not interbreed with the latter. *Perplexa* also closely resembles very dark specimens of *spiraeae,* and here as in the preceding case a determination of the food plant is probably the safest means of identification.

G. decora Say. Form oblong oval, subdepressed, moderately elongate, not much wider behind. Color dull yellow, brown or even piceous (var. *carbo*). The head is always broadly piceous posteriorly, the thorax more or less distinctly trimaculate, the body beneath in great part black or piceous. Antennae piceous, the proximal parts of the basal joints usually more or less paler; legs dull yellow except in var. *carbo*. Upper surface always distinctly pubescent, typically rather densely so. Prothorax nearly twice as wide as long, narrowed in front, angles a little prominent, base obliquely sinuate at sides and feebly so at middle; disk impressed medially and with a rather broad but shallow depression each side; surface rather densely and finely rugose and

opaque, the feeble convexities on either side of the median impression smoother than in any of the allied forms. Elytra moderately, coarsely, not very closely punctate. Length 4.5 to 5.5 mm.

Male. Last ventral broadly emarginate at tip, the disk with a deep ovate-triangular apical impression with acute margins; claws finely bifid at tip.

Female. Last ventral not or very feebly and broadly emarginate, but with a short apical longitudinal line or scar like erosion, which is often obsolete; claws a little more widely bifid.

This species is widely dispersed over the northern states and Canada from the Atlantic to the Pacific. Within that wide range a good deal of variation is observable even after eliminating several of the new species here described, which have hitherto been confused with it. It is therefore by no means impossible that a further splitting up may be called for when the life histories of some of these forms or races, especially from the western half of the continent shall have been worked out. Say's type, made known one hundred years ago from the "North West Territory," is described as "dusky, elytra dull testaceous sericeous with brilliant, dense, prostrate, golden brassy hairs." In a good many of the New England specimens that I have seen, the pubescence is too thin to even passably satisfy this description; but in others it is denser with an obvious silky sheen. These latter for present purposes I shall assume to be true exponents of Say's species, while the more thinly pubescent forms will be associated as representing local or racial variations, until further light is shed upon the relationship. The one character which in mature specimens at once distinguishes all these from the preceding species, is the broadly piceous occiput and under body.

Throughout its range *decora* is recognized as a willow feeder. I have, however, received from Mr. F. S. Carr of Edmonton, Alberta, specimens taken by him on willow, and others from "black poplar" that are absolutely identical. A small series taken by myself on poplar at Tyngsboro, Mass. are redder in color and more thinly pubescent than in the usual form from willows; they are, however, not believed to differ specifically.

Part Two. Economic and Biological.[4]

BY WILLIAM COLCORD WOODS.

SUMMARY

The chrysomelid beetles of the genus *Galerucella* are clearly divisible into two series, one in which the elytra are striped or vittate, and another in which they are not. 11 species of this genus are known to occur in Maine, and these together with 4 other New England species are treated in this bulletin.

5 of the Maine species, the blueberry leaf-beetle, the gray willow leaf-beetle, the brown willow leaf-beetle, the cherry leaf-beetle and the imported elm leaf-beetle are of considerable economic importance. The biology and control of the blueberry leaf-beetle and the two willow leaf-beetles are discussed in detail, while briefer notes are given concerning the other species.

Following is a list of the 15 species of *Galerucella* included in this paper, with their respective food plants. The 4 species not yet taken in Maine are indicated by an asterisk.

Vittate series:

**americana* Fab.....food plant not certainly known (page 137).
**conferta* LeC.....food plant not certainly known (page 137).
cribrata LeC.....golden-rod (page 137).
notata Say.....thoroughwort (page 137).
**notulata* Say.....Roman wormwood (page 138).
nymphaeae L.....pond-lily and knotweed; adults will take willow, elm, and bean; a race on sweet gale (page 134).
xanthomelaena Sch....elm (page 136).

Non-vittate series:

cavicollis group:

cavicollis Say.....cherry (page 133).
kalmiae Fall.....laurel (page 127).
**rufosanguinea* Say....azalea (page 133).

decora group:

alni Fall.....alder (page 115).
decora Say.....willow (page 105).
perplexa Fall.....willow (page 112).
spiraeae Fall.....meadow-sweet (page 122).
vaccinii Fall.....blueberry (page 93).

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[4]Papers from the Maine Agricultural Experiment Station: Entomology No. 116 and Contribution from the Biological Laboratory of Wesleyan University, Middletown, Connecticut.

THE BLUEBERRY LEAF-BEETLE, GALERUCELLA VACCINII

Biological Notes.

TYPICAL LIFE-HISTORY.

The following is cited as a typical life-history:

7 eggs deposited on June 24 hatched on July 10.
7 larvae molted to the second instar on July 15.
7 larvae molted to the third instar on July 20.
3 larvae entered soil as prepupae on July 23.
2 prepupae transformed to pupae on July 28.
1 pupa emerged as an adult on August 4.
1 pupa emerged as an adult on August 5.
1 prepupa died before transforming.
3 larvae entered soil as prepupae on July 24.
3 prepupae transformed to pupae on July 29.
3 pupae emerged as adults on August 5.
1 larva died before entering the soil.

SUMMARY OF REARINGS.

Length of the egg stage. A record which was kept of 146 eggs deposited from May 31 to July 3 may be tabulated as follows:

2 hatched in 14 days, 3 in 15 days, 41 in 16 days, 47 in 17 days, 6 in 18 days, 12 in 19 days, 4 in 20 days, 1 in 21 days, 4 in 22 days, 10 in 23 days, 4 in 24 days, 3 in 26 days, 4 in 28 days, 2 in 29 days, 1 in 30 days and 2 in 31 days; average 18 (17.6) days.

Length of the first larval instar. A record which was kept of 88 larvae which hatched between June 29 and August 1 may be tabulated as follows:

1 molted to the second instar in 3 days, 34 in 4 days, 42 in 5 days, 6 in 6 days, 2 in 7 days and 3 in 8 days; average 5 (4.7) days.

Length of the second larval instar. A record which was kept of 72 larvae which molted to the second instar between July 6 and August 7 may be tabulated as follows:

19 molted to the third instar in 3 days after the first molt, 16 in 4 days, 31 in 5 days, and 6 in 6 days; average 4 (4.3) days.

Length of the third larval instar. A record which was kept of 66 larvae which molted to the third instar between July 12 and August 12 may be tabulated as follows:

5 entered soil in 2 days after the second molt, 12 in 3 days, 26 in 4 days, 8 in 5 days, 4 in 6 days, 8 in 7 days, 2 in 8 days, and 1 in 9 days; average 5 (4.6) days.

Length of the prepupal period. A record which was kept of 81 prepupae which entered soil between July 18 and August 13 may be tabulated as follows:

2 transformed to pupae in 3 days after entering soil, 7 in 4 days, 34 in 5 days, 22 in 6 days, 8 in 7 days, 2 in 8 days, 1 in 9 days and 1 in 10 days; average 6 (5.5) days.

Length of the pupal instar. A record which was kept of 73 pupae which transformed between July 27 and August 20 may be tabulated as follows:

6 emerged as adults in 6 days after the pupal molt, 25 in 7 days, 25 in 8 days, 14 in 9 days, 2 in 10 days and 1 in 11 days; average 8 (7.7) days.

SEASONAL HISTORY IN MAINE.

The blueberry leaf-beetles pass the winter as adults hidden away in the debris at the base of the blueberry bushes. They leave their winter quarters quite early, and begin to feed on the expanding leaf-buds and to pair. They may be found in the field even before the blueberry blossoms shed pollen, mid-May in eastern Maine. A few days later, when the flowers are shedding pollen quite generally, the first eggs are laid, May 21 being the earliest date recorded. The females may continue to deposit eggs at least as late as July 26, though the bulk of oviposition occurs during the latter part of June and early July. The overwintering adults are not common in the field after mid-July; one longevous female lived in the laboratory until August 6. The length of the egg stage varies from 2 weeks to one month, the larval life (including the prepupal period) occupies on the average 20 days, and the pupal 8. The earliest date on which the writer has bred an adult of the new generation is July 8, but the new generation of beetles does not become common until much later in the month. As the oviposition period lasts more than two months, all stages of this insect may be found simultaneously, but

the adults which emerge each summer neither pair nor oviposit until the next, although they do feed freely on the foliage until well into the fall before they seek hibernating quarters.

DISTRIBUTION.

This species is generally distributed in Maine; the writer has taken specimens in Hancock County (Bar Harbor, Ellsworth, Lamoine), Penobscot County (Enfield, Orono, and Searsport), Waldo County (Freedom), and Washington County (Cherryfield and Harrington). Doctor Fall has specimens from New Hampshire and Massachusetts.

Description and Activities.

THE EGG.

Description. The egg is nearly spherical, yellow or slightly orange in color. The surface is beautifully and deeply sculptured with somewhat irregular hexagonal areas. The eggs average about .8 mm. x .6 mm. in diameter.

Deposition. Although the eggs are easily obtained in the laboratory, they are very hard to find in the field since they are deposited in crevices or roughnesses at the base of the stem, and are thus effectively concealed. The eggs are soft when first deposited, but soon harden; however, they remain yellow, not turning brown as they do in many species of this genus and the mother beetle does not deposit fecal matter with the eggs, a practice that aids concealment common among the leaf-beetles.

Hatching. The egg turns gray 24 hours before the larva emerges. An irregular slit is formed near the head end of the egg through which the larva crawls out, rapidly once the head and legs have been forced through the opening.

THE LARVA.

Description of full grown larva. Body eruciform, elongate and more or less cylindrical, and of comparatively uniform diamater; head, thorax and abdomen distinct, the thorax composed of 3 distinct segments each bearing a pair of jointed legs, the abdomen composed of 10 segments, the last bearing a single anal pro-

leg; the prothorax and the 9th abdominal segment strongly chitinized dorsally to form the prothoracic and anal shields respectively; thoracic and abdominal segments with setiferous tubercles[5] as described below; length 6-6.5 mm. Figure 15B is reproduced from a photograph of the larva.

Head directed obliquely forward and downward, strongly chitinized, varying in color from light to dark brown or even black, the suture lines usually white and the median apodeme black; a single large ocellus on each side of the head, situated in the epicranium; dorsad of and slightly posterior to the antenna; otherwise as described for *Altica* (Bul. 273, p. 158) except for the cephalic setae which in this and other species of *Galerucella* are too variable to show any typical arrangement.

Body wall of the thoracic and abdominal segments greenish yellow, densely beset with light brown cuticular nodules; the prothoracic and anal shields and all of the tubercles brown; spiracles black; proleg greenish yellow.

Abdominal segments 1 to 8 bear setiferous tubercles of identical arrangement, as follows: an anterior dorsal tubercle (right and left tubercle i confluent across the mid-dorsal line) and a slightly wider posterior dorsal tubercle (tubercles ii and iv of each side confluent with each other as well as across the mid-dorsal line); 3 small dorso-lateral tubercles, 2 anterior and one posterior (ii, v and vi respectively); the spiracle is borne on a non-setiferous tubercle between the dorso-laterals and the large lateral tubercle (fused vii and viii); a ventro-lateral tubercle (fused ix and x); and an anterior and a posterior ventral tubercle, of which the anterior (xiii) fused with its fellow of the opposite side forms a row of mid-ventral tubercles, and the posterior (fused xii and xiv) is smaller and distinct from its fellow.

Arrangement of setae. The arrangement of the setae can be expressed more clearly by diagram than explained in words; the setal pattern of the larvae is shown in figure 13, A, B and C. The setae are of 2 sorts, some larger and some smaller; the larger or primary setae which doubtless correspond to the setae found in *Altica* are relatively constant in their occurrence, while the smaller or secondary setae are subject to great variation. In the diagrams in this bulletin, the maximum complement of setae found in each species figured is represented on the left side of the larvae, while only the larger or primary setae are shown on the right. It should be added that almost always some and rarely all of the secondary setae are wanting, while on the other hand these accessory setae may occasionally be almost as well developed as the primary setae, so that, although the number and position of the setiferous tubercles is as constant in each species of *Galerucella* studied as in *Altica*, the number of setae, so constant in the latter genus, is quite variable in the former.

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[5]The tubercles of the larvae of the species of *Galerucella* described in this bulletin are numbered as those of the *Altica* larvae described in bulletin 273 (pages 157 and 158).

Abdominal segment 9 is modified dorsally into a strongly chitinized anal shield (interpreted as representing a fusion of tubercles i through viii), and bears ventrally a single large median tubercle (interpreted as representing tubercles xiii and xiv of each side fused together and across the mid-ventral line). Such variation was found in the setal pattern of the anal shield in this and other species that these setae are not shown in the diagrams.

Abdominal segment 10 is very small; it has no tubercles nor setae, but bears ventrally the greenish yellow anal proleg; the anal opening, shaped like an inverted Y, lies in the middle of the proleg.

Metathorax. On each side an anterior and a posterior dorsal tubercle (tubercle i and tubercle ii respectively), the anterior the larger; a small anterior and a small posterior dorso-lateral tubercle (tubercle iii and a fusion of iv and vi respectively); a large lateral tubercle bearing 4 large setae (interpreted as a fusion of tubercles v, vii and viii, with one seta each for v and vii and 2 for viii); a small anterior and a small posterior ventro-lateral tubercle (ix and x respectively); an anterior and a posterior tubercle (xi and xii) associated with the base of the leg, the former strongly chitinized and non-setiferous, the latter bearing one large seta; and an anterior and a posterior ventral tubercle (xiii and xiv respectively), the former fused with its fellow across the mid-ventral line, the latter not.

Mesothorax. Exactly like the metathorax except that a spiracle is present above the seta on the anterior ventro-lateral tubercle (ix).

Prothorax. Modified dorsally into a strongly chitinized prothoracic shield, formed by the fusion of tubercles i through viii; a single large ventro-lateral tubercle (fusion of ix and x); tubercles xi and xii as in the other thoracic segments are associated with the base of the leg, but both are non-chitinized and setiferous instead of only xii; and a single large somewhat horse-shoe shaped mid-ventral tubercle, representing a fusion of tubercles xiii and xiv with each other and across the mid-ventral line. Such variation was found in the setal pattern of the prothoracic shield in this and other species that these setae are not shown in the diagrams.

Spiracles. There are 9 pairs of spiracles, 8 abdominal and one thoracic. The abdominal spiracles are borne on unnumbered and non-setiferous tubercles just above the lateral tubercle on the first 8 abdominal segments; the thoracic spiracle is borne on the anterior ventro-lateral tubercle (ix) of the mesothorax.

Legs. The legs are each composed of 5 segments; the proximal segment fits closely into a socket formed by the infolded body wall with which it is continuous, and articulates slightly with tubercle xi, tubercle xii being contiguous caudad; the fourth segment is the longest; the short strongly chitinized distal segment bears a single pulvillus and a single inward-curved claw. (Since it appears to the writer that the imaginal disc from which the leg of the beetle is formed lies at the base of the larval leg, and since during the prepupal period the hypodermis is apparently withdrawn from the larval leg, it does not seem wise at present to try to homologize the parts of the leg in the two stages.)

Description of just hatched larva. Arrangement of setae and tubercles the same, the tubercles proportionately larger and closer together; head proportionately larger; setae capitate (those of the later instars being hollow but not capitate); length 1.33 mm. to 1.5 mm.

Head measurements. During the first instar the width of the head was found to vary from .38 mm. to .43 mm.; during the second instar from .50 mm. to .52 mm.; and during the third instar from .67 mm. to .74 mm.

These head measurements are different from those given in Bulletin 244 page 287, and should supercede them. The larvae recorded in that paper were taken by sweeping, and all measured were not *vaccinii* Fall but *kalmiae* Fall, for one frequently takes both species of *Galerucella* by sweeping since blueberry and sheep laurel in Maine usually grow together, and at the time of writing the blueberry bulletin, the writer, knowing *kalmiae* only as a larva, was not aware that he was confusing 2 distinct species of *Galerucella,* the one living on the blueberry and the other on the sheep laurel.

Color changes of larva during growth. The body-wall of the larva is covered with minute cuticular nodules which together with the tubercles are the pigmented portions of the integument. Just after hatching or immediately after a molt, the skin is translucent and the larva appears entirely greenish yellow, as no pigment has yet been formed and the fat-body shows through the cuticula. In a few hours pigment appears in the tubercles and the nodules. As the body wall is not stretched the tubercles and nodules lie close together and give the larva a dark aspect; later in the instar the general body color appears much lighter, since the integument is stretched, the tubercles therefore constituting a smaller proportion of the body surface and the nodules lying farther apart. Such a series of color changes is characteristic of many chrysomelid larvae.

Color description of the instars. Early in the first instar, the head and legs of the larva are deep shining black, and the shields dark shining brown; the tubercles are dark brown, the spiracles black; the unpigmented portions of the cuticula and the anal proleg are greenish yellow, but the general aspect of the larva is dark. The coloration is similar at the end of the instar but the general aspect is much lighter. The coloration of the second and third instars is identical. Early in the instar the head is shining brown, occasionally a dark brown and rarely black;

the legs are dark brown or black; the shields and tubercles are brown, the spiracles black; the unpigmented portions of the cuticula, and the proleg, are greenish yellow, but the general aspect is quite dark, while later in the instar the aspect is quite light.

Molting and coloration. Both the first and second molts are accomplished in the same way.

When ready to molt the larva fastens itself securely to the leaf by the thoracic legs and the proleg. Then the old cuticula begins to crack first on the mid-dorsal line of the mesothorax, this split 3 or 4 minutes later extending backward into the metathorax and forward into the prothorax and along the epicranial suture of the head. Through the opening thus formed the body is forced out hunch-back like, the thoracic segments bulging out first in a strongly arcuate condition before the head is freed. The movement is due to the slow regular contraction and alternate relaxation of the body muscles, correlated with changes of the blood pressure in the different parts. In 8 or 9 minutes from the time of the original split, the head is freed and the legs are drawn out all together almost immediately afterwards, and held closely appressed to the body. The thoracic segments as well as the head are thus completely free from the old cuticula at this time. The molting of the reddish intima of the fore-intestine can be observed plainly shortly after the mouth parts are freed, as well as that of the successive tracheae in turn. The new setae are not formed within the old ones but lie flat, pressed down between the two cuticulas; they spring up into position as soon as the old cuticula is shed. The segments of the abdomen are freed more gradually but usually all except the last 2 or 3 are completely exposed within 20 or 25 minutes. The larva is now attached to the leaf by the anal proleg and by the "tarsal" claws of the old cuticula which remain firmly imbedded in the leaf substance. In a few minutes more, after the new cuticula has become somewhat hardened, the larva bends over so as to rest its thoracic legs on the substratum—it has, so to speak, been sitting on its tail up to this point—and, releasing the hold of the anal proleg, walks feebly off, and is thus completely free from the old cuticula. The intima of the hind-intestine is molted just as the larva releases its hold with the proleg; this is the hardest part of the entire molt to observe.

As the larva molts, it is entirely greenish yellow, the color of the fat-body, including the head, legs and shields; only the ocelli and the spiracles are black, and the mandibles reddish brown. No considerable change in coloration is apparent for about an hour, but by that time head and legs are light brown or gray, and the tubercles are slightly pigmented. The normal coloration is attained in about 2 hours and a half.

Feeding habits. The larvae eat only the leaves of their host-plant, feeding exclusively on the under surface. They destroy the lower epidermis and the mesophyll, leaving a network of even

the finer veins, and the upper epidermis which turns brown. They are usually solitary, only one larva to a leaf. The characteristic work is shown in figure 15K.

THE PREPUPA.

As soon as the larvae enter the prepupal period they desert the leaves and seek the ground, entering any fairly loose soil in which they form a rude cell not far below the surface. In this cell the pupa is formed. The cell is hollowed out by the contortions of the body, and the lining earth rudely cemented by secretions from the maxillary glands, for the *Galerucella* like *Altica* and many other beetle larvae lack true salivary (labial) glands. At first the prepupa is indistinguishable from the larva except on dissection, but in a few days the body becomes strongly arcuate, the color yellower, and, due to the degeneration of the larval muscles the insect is not able to use its legs. The cuticular pigmentation becomes duller and lighter.

THE PUPA.

Description of just formed pupa. Uniformly yellow; caudal spines black; spiracles usually black, except those of abdominal segments 6 and 7 which if present are brown; setae dark brown; length about 4.5 mm.

The pupa is shown in figure 13 D-G and figure 15 D-E. The head is bent ventrad; the 3 thoracic segments are distinct; and there are 8 abdominal segments in addition to the anal plate.

There are 2 setae on each side of the head, and on each side of the mesothorax and the metathorax. Normally there are 2 setae on each side of the first 7 abdominal segments, one near the mid-dorsal line and one just below the spiracle, although rarely extra setae may be present between them. The 8th segment bears a large caudal spine on each side, and 4 small setae (any one of which may be wanting). The anal plate bears no setae. There are 2 apical setae on each femur. All of these setae are on the dorsal side, for the pupa lies with the ventral aspect uppermost and the function of these setae is to keep it from contact with the sides and floor of the pupal cell.

8 pairs of spiracles may be present. The first pair is located on the mesothorax ventrad of the base of each elytron. The

other 7 pairs are located on the first 7 abdominal segments; the first 5 pairs are larger than the last two which are not infrequently wanting on one or both sides.

The setal pattern of all members of the *decora* or *cavicollis* group is similar except in the arrangement on the prothorax. What seemed to be the typical pattern is illustrated for each species, although in a large series considerable variation may be noted.

Description of pupa ready to transform. Head brownish, eyes black, mandibles and antennae dark brown; prothorax irregularly splotched dorsally with gray brown; metathoracic apodemes brown; spiracles black; legs, especially the tarsi, brownish; elytra very light yellow brown, appearing almost black as the dark gray wings show through them; abdomen yellow both dorsally and ventrally, becoming somewhat brownish 24 hours before the emergence of the adult.

Color cycle of pupa. When the pupa is first formed it is pure yellow except for the setae, spiracles, and caudal spines. As it grows older certain color changes appear very constantly, correlated with the progress of internal metamorphosis. Brown pigment appears in the eyes on the second day, they are dark brown on the 3rd and black on the 4th; the mandibles are red brown on the 5th day; the wings are gray on the 6th day or 48 hours before emergence and black on the 7th or 24 hours before emergence. There is some variation, these color changes appearing a day or 2 later in some individuals than others but the sequence of the changes and the pigmentations themselves are constant.

The molt from prepupa to pupa. This molt is by far the most difficult in the life cycle, and the mortality is far greater than at any other crisis. In principle it is exactly like the larval molts. The old cuticula cracks along the mid-dorsal line of the mesothorax, the crack extending cephalad along the prothorax and the epicranial suture, and caudad into the metathorax. Very slowly and gradually the pupa wriggles out thru the crack thus formed, the molt occupying at least an hour and frequently longer. Like the larval molts, it is accomplished by alternate tension and relaxation of the body muscles, accompanied by changes in the blood pressure.

THE ADULT.

Description. See page 88 of this bulletin. Figure 15C is reproduced from a photograph of the adult.

Emergence and coloration. As has been stated above, the pupa lies with the ventral aspect uppermost, but some 24 hours before the beetle is ready to shed the pupal cuticula, the imaginal organs are so well formed that the legs have some freedom of use, and when the insect is actually ready to accomplish the molt, the elytra and wings are pushed dorsad (without change in size) and the legs are more or less straightened out.

The old cuticula is split through the agency of the scutellum which is raised up and down until the skin is ruptured on the mid-dorsal line of the mesothorax, the split extending rapidly up the prothorax and less rapidly (5 to 7 minutes) down the metathorax. Within 8 minutes from the time of the cracking, the pronotum, the mesonotum and the metanotum are exposed, the tergites of one or two abdominal segments, and the head as far as the mouth parts. Within 10 minutes the molt will have proceeded so rapidly that not only all of the mouth parts are free from their pupal cases, but two-thirds of the elytra, the prothoracic legs as far as the tibiae, and 5 or 6 segments of the antennae. The intima lining the pupal fore-intestine is shed immediately after the mouth-parts are freed. 5 minutes more suffice to clear three-quarters of the elytra from their covering, most of the prothoracic and mesothoracic legs, the metacoxae, and all but the distal antennal segments; not long after, the antennae are freed, and one or another of the thoracic legs. As soon as any of the thoracic legs are free, the beetle uses them vigorously to push back the pupal skin, and within 5 minutes from the time one is out all are clear of their old cuticular cases. In 25 or 30 minutes from the time the molt starts, the old cuticula is kicked off the tip of the abdomen, though it usually remains tangled in the tarsal claws for many hours before it is entirely cast off. The intima lining the tracheae is molted as the pupal cuticula passes off their respective segments, and the intima of the hind-intestine is shed as the last kick pushes the pupal skin off the tip of the abdomen.

Sometimes the antennae are freed before any of the legs, sometimes not until after all, are clear of the pupal cuticula, and the order in which the thoracic legs are freed is subject to all possible variations, sometimes even the metathoracic being the first.

The beetle is light yellowish when it emerges from the pupal cuticula, and the body is very soft. The eyes are black, the antennae brown, as are also the pronotum, mandibles and tarsi. Fully 40 hours are required for the coloration and hardening of the cuticula, and the beetle does not leave the pupal cell until it has fully hardened. Most of this time the insect is still lying on its back, for like the pupa, the imago is formed with the ventral aspect uppermost. The coloration proceeds more rapidly dorsally than ventrally, and most rapidly of all in the elytra.

Feeding habits. The adults "skeletonize" the leaves as do the larvae, and the feeding of the 2 stages is almost indistinguishable. The beetles feed freely in the fall before entering into hibernation, and in the spring after they come out from their winter quarters, both before and after copulation and hibernation.

Breeding habits. Copulation may take place several times a season. The greatest number of eggs deposited by a single female was 388; this individual, taken in copulation on June 4, deposited her complement of eggs between June 5 and July 26, and died on August 6, with the record for longevity in this species, for maximum egg production, and for the greatest number of eggs (26) deposited by one individual in 24 hours.

Food Plants.

Natural food plants. In nature the writer has found this species only on the low sweet blueberry.

Food plant tests. Extensive food plant tests were made with this and other species of the genus comparable to those made of *Altica* (Bul. 273, p. 171). Larvae and adults of the blueberry leaf-beetle were tested with 83 species of plants, representing many different families.

Both larvae and adults ate readily the following species: *Vaccinium pennsylvanicum* Lam. (low sweet blueberry), *V. canadense* Kalm (velvet leaf blueberry), *V. vacillans* Kalm (late low blueberry), *V. corymbosum* L. (high bush blueberry) and *V. atrococcum* (Gray) Heller (black high blueberry).

All other food tests were negative, both for larvae and adults. The following (among those which were not eaten) have special significance because they are primary food plants of other species of *Galerucella:* alder, boneset, elm, golden-rod, meadow-sweet, red cherry, sheep laurel, sweet gale, willow and yellow pond-lily.

The following plants of the family Ericaceae (heath family) to which the genus *Vaccinium* belongs were tested with negative results: *Andromeda glaucophylla* Link (bog rosemary), *Chamaedaphne calyculata* (L.) Moench (cassandra), *Gaylussacia baccata* (Wang) C. Koch (black huckleberry), *Kalmia angustifolia* L. (sheep laurel), *Ledum groenlandicum* Oeder (Labrador tea), *Rhododendron canadense* (L.) BSP (rhodora), *R. nudiflorum* (L.) Torr. (purple azalea) and *Vaccinium macrocarpon* Ait. (large cranberry).

Apparently this species is confined to the genus *Vaccinium* L., subgenus *Cyanococcus* Gray, or true blueberries. Both larvae and adults ate the 5 species of this subgenus found in New England, and refused all other plants offered them.

NATURAL ENEMIES.

No insects were found either as parasitic or predaceous enemies of the blueberry leaf-beetle in any of its stages.

In common with all related beetles, it is very susceptible to the attacks of a parasitic fungus, *Sporotrichum globuliferum* Speng., under the right conditions both in the laboratory and in the field. This widely distributed fungus destroys many of these insects when the conditions are favorable, and doubtless is an important agent in holding this as well as other leaf-beetles in check.

Both prepupae and pupae are quite commonly subject to a wilt disease, probably bacterial in its nature.

CONTROL.

Next to the blueberry maggot (a biological race of *Rhagoletis pomonella* Walsh) and the periodically abundant blueberry flea-beetle (*Altica cupraseens* Blatchley, discussed as *A. torquata* Leconte in Bul. 273 p. 194-202), this present species is the most serious insect enemy of Maine blueberries. When the beetle is very abundant for 2 or 3 successive seasons it may kill off the blueberry bushes over quite large areas.

On the barrens, in common with other leaf-feeding insects, this species is held in control by the periodic burning over of the plains. In other parts of the State blueberries grow for the most part on uncultivated land where control measures are not feasible. Wherever spraying is practicable, any stomach poison such as arsenate of lead is effective against this insect. Arsenate of lead, if employed in the powdered form, should be used at the rate of 1½ pounds per 50 gallons of water; the first application should be made in late May for the beetles, and if necessary a second in July for the larvae. The paste form is to be used at double the above rate. In most cases dusting would be easier than spraying and equally effective. Applied as a dust, arsenate of lead may be greatly diluted, using it at the rate of one part to

7 or 8 parts of some inert substance such as finely powdered gypsum or flour. Whenever spraying is done especially on wild land the possible poisoning of grazing animals and of humans must be reckoned with and guarded against.

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1915. Me. Agr. Exp. Sta. Bul. 244 p. 286-288 (*G. decora* Say).

THE GRAY WILLOW LEAF-BEETLE, GALERUCELLA DECORA SAY.

Biological Notes.

TYPICAL LIFE HISTORY.

The following is cited as a typical life history:

3 eggs deposited on July 17 hatched on August 3.
3 larvae molted to the second instar on August 8.
3 larvae molted to the third instar on August 12.
3 larvae entered the soil as prepupae on August 17.
3 prepupae transformed to pupae on August 20.
3 pupae emerged as adults on August 27.

Summary of Rearings.

Length of the egg stage. A record which was kept of 46 eggs deposited from July 7 to July 17 may be tabulated as follows:

28 hatched in 9 days, 9 in 10 days, 6 in 11 days, 1 in 12 days and 2 in 18 days; average 10 (9.9) days.

Length of the first larval instar. A record which was kept of 41 larvae which hatched between July 17 and July 20 may be tabulated as follows:

24 molted to the second instar in 3 days, 10 in 4 days and 7 in 5 days; average 3 (3.4) days.

Length of the second larval instar. A record which was kept of 22 larvae which molted to the second instar between July 20 and August 8 may be tabulated as follows:

20 molted to the third instar in 3 days after the first molt, 1 in 4 days and 1 in 6 days; average 3 (3.2) days.

Length of the third larval instar. A record which was kept of 20 larvae which molted to the third instar between July 23 and August 12 may be tabulated as follows:

1 entered soil in 2 days after the second molt, 6 in 3 days, 8 in 4 days, 3 in 5 days and 2 in 6 days; average 4 (4.3) days.

Length of the prepupal period. A record which was kept of 14 prepupae which entered soil between July 26 and August 17 may be tabulated as follows:

3 transformed to pupae in 3 days after entering soil, 5 in 5 days and 6 in 6 days; average 5 (5.0) days.

Length of the pupal instar. A record which was kept of 14 pupae which transformed between August 1 and August 20 may be tabulated as follows:

7 emerged as adults in 6 days after the pupal molt and 7 in 7 days; average 7 (6.5) days.

SEASONAL HISTORY IN MAINE.

Hidden away in protected places near their food plant, the gray willow leaf-beetles pass the winter as adults. They are in no hurry to quit their winter quarters and do not appear until the willow leaves are well expanded, usually in early June. Then they begin to feed and to pair immediately. The adults may be taken commonly in the field until mid-July when they begin to be scarce, and the latest date to which one has lived in the laboratory is August 10. Adults of the new generation are common in the field by August 20; August 5 is the earliest date on which the writer has bred one through in the laboratory. The earliest date on which the writer has taken eggs of this species is June 15; the latest on which they have been deposited in the laboratory, July 31. But few are deposited after July 20. There is only one generation each year, and no indication of a second under any conditions.

DISTRIBUTION.

In Maine the writer has taken this species in Enfield and Orono, both in Penobscot County. It is probably generally distributed through the State. Doctor Fall has taken specimens in Tyngsboro, Mass. It is reported in the economic literature from Manitoba, British Columbia, New York and New Jersey.

Description and Activities.

THE EGG.

Description. Almost spherical, sculptured like that of *vaccinii* Fall; dull brown in color; diameter about .8 mm. by .6 mm.

Deposition. The eggs are deposited about the base of the host plant, mostly in rough places in the bark. They are very difficult to find in the field, a characteristic of the whole *decora* group. When first deposited, the eggs are soft and yellow, but as they harden they become brown in a few hours. They turn gray 24 hours before hatching. The female deposits them at the rate of 2 per minute, covering them with fecal matter.

Hatching. The process of hatching is the same as that described under the blueberry leaf-beetle. The normal coloration is attained in about 2 hours and a half.

THE LARVA.

Description of full grown larva. Except as noted below, the full grown larva is similar to that of the blueberry leaf-beetle, described on page 95 of this bulletin:

A considerable difference in the setal pattern as may best be seen by reference to figures 14 A, and B. Note also that the anterior dorsal tubercle is wider than the posterior in the abdominal segments of this species.

A very marked difference in the coloration as follows: head varying in color from light shining brown to shining black, the sutures usually white, ocelli black; legs varying from light gray to shining black, usually light gray with the distal borders of the segments and the entire distal segment black; prothoracic shield rarely entirely shining black, but usually unpigmented except on each side of the mid-dorsal line; anal shield unpigmented; dorsal tubercles (both anterior and posterior) black, forming a black mid-dorsal line from the prothorax through the 8th abdominal segment, continuous early in the instar, more broken later (there is much

variation in this stripe, which is narrower and shorter in some individuals than in others); all other tubercles uncolored except the lateral tubercles of the mesothorax and metathorax which are edged with dark gray or brown, and very rarely the lateral tubercles of the abdomen which are usually unpigmented may be light gray; spiracles black; general body color creamy or grayish white; anal proleg creamy white; length 7-7.5 mm.

Description of just hatched larva. Arrangement of setae and tubercles the same, the tubercles proportionately larger and closer together; head proportionately larger; setae capitate; coloration as described below strikingly different; length 1.3 mm.

Head measurements. During the first instar the width of the head was found to vary from .40 mm. to .45 mm.; during the second instar from .55 mm. to .62 mm.; and during the third from .71 mm. to .83 mm.

Color changes of larva during growth. A series of color changes comparable to that described for the blueberry leaf-beetle is equally characteristic of this species. There is moreover a very striking color change between the first and second instars, all of the tubercles being brown in the first instar and most of them unpigmented in the later instars.

Color description of the instars. In the first instar the head, legs, prothoracic and anal shields shining black; tubercles brown; body creamy white, general aspect dark (early in the instar) or light (later in the instar); spiracles black; anal proleg creamy yellow. In the second and third instars the tubercles are uncolored except the dorsal tubercles which are black as has been described. The coloration of these two instars is identical.

"Reversion" larvae. The typical appearance of a second or third instar larva is creamy white, with a heavy black middorsal stripe. But in rare instances larvae were found in these instars which were colored as in the first instar: that is, all of the tubercles were pigmented and the dorsal tubercles brown like the others instead of black, and but little darker than the rest. The arrangement of the setae was identical with that of the more normal larvae. The occurrence of these larvae in this color phase would seem to indicate, as one would guess from other considerations, that the striking coloration of the older larvae is a derived condition, and that the coloration of the first instar is the more primitive. Larvae which are of this "reversion" coloration in the second instar may be of the normal coloration in the third, but no instance was observed in which a larva was of

the normal coloration in the second instar but of the reversion type in the third.

Molting and coloration. The process of molting is exactly the same as that described for the blueberry leaf-beetle. Both molts are alike, and the normal coloration after each molt is acquired in about 2 hours.

Feeding habits. The larvae finely skeletonize the leaves of their host plant. They feed exclusively on the under side of the leaves, and usually there is only one larva on a leaf. They leave a net-work of even the finer veins, eating the mesophyll and the two epidermises. Their characteristic work is shown in figure 15J.

THE PREPUPA.

The prepupal cell is formed as in the case of the blueberry leaf-beetle. The prepupa becomes progressively yellower and more arcuate, and the cuticular pigments duller.

THE PUPA.

Description of just formed pupa. Coloration similar to that described for *vaccinii* (page 100); setal pattern similar except for the setae of the prothorax, shown in figure 14F; length about 4.5 mm.

Color cycle of pupa. As the pupa grows older certain color changes appear, correlated with the progress of the internal metamorphosis. Usually the eyes appear very light brown on the second day and are black by the 3rd, the mandibles becoming red brown about the same time. Forty-eight hours before emergence the wings are light gray and almost black 24 hours before.

Description of pupa ready to transform. The coloration is similar to that described for the blueberry leaf-beetle.

THE ADULT.

Description. See page 90 of this bulletin.

Emergence and coloration. The emergence of the adult is exactly like the process described for the blueberry leaf-beetle. About 24 hours are required for the hardening of the cuticula and the development of the color pattern.

Feeding habits. The adults skeletonize the leaves somewhat as do the larvae but their feeding is distinguishable as they skeletonize more coarsely, eating the finer veins which the larvae reject and leaving a net-work of only the larger veins. This work is illustrated in figure 15 H-I. They feed in the fall before entering winter quarters and in the spring after they come out from hibernation, both before and after copulation and oviposition.

Breeding habits. Copulation usually takes place several times each season. The largest number of eggs deposited by a single female was 175. This beetle mated on June 14 and deposited eggs between June 15 and July 16, dying on July 24. The greatest number which any individual female was observed to deposit in 24 hours was 31. The eggs are deposited in clusters of from 3 to 37, usually about 15.

FOOD PLANTS.

Natural food plants. In nature the writer has taken these beetles only on various species of willow. In Maine at least the beaked willow, *Salix rostrata* Richards is the preferred host; then *S. discolor* Muhl., *S. petiolaris* Sm., and *S. cordata* Muhl. in the order named. Criddle has recorded them from poplar (1911 and 1912, stating in the latter reference that they breed on willow) and Doctor Fall has taken them on poplar in Massachusetts. All other references in the literature when the host plant is given are to "willow."

Food plant tests. Larvae and adults were tested with 67 species of plants representing many different families. Both larvae and adults ate readily all species of *Salix* and *Populus* offered them and refused all other food. The following species of willow were tested: heart-leaved willow, *Salix cordata* Muhl.; glaucous willow, *S. discolor* Muhl.; black willow, *S. nigra* Marsh; petiolate willow, *S. petiolaris* Sm.; and beaked willow, *S. rostrata* Richards. The following species of poplar were tested: aspen, *Populus tremuloides* Michx.; balsam poplar, *P. balsamifera* L.; cottonwood, *P. deltoides* Marsh; and large toothed aspen, *P. grandidentata* Michx. As these tests were all positive it seems a fair inference that the gray willow leaf-beetle will eat all species of willow and poplar.

All other food plant tests were negative. The following which were not eaten by the gray willow leaf-beetle have special significance, as they are the primary host plants of other species of this genus: alder, azalea, boneset, elm, golden-rod, meadow-sweet, red cherry, sheep laurel, sweet gale and yellow pond-lily.

Natural Enemies.

The remarks under the blueberry leaf-beetle (page 104) apply with equal force here.

Control.

This species is of considerable economic importance in such regions as central New York where the raising of willows for baskets is an important industry. The willow is little used in Maine, and as long as this species confines its attention to the willow, it will not be a serious pest in this State. But it must be reckoned a potentially dangerous insect for it can exist on any of the poplars just as well as on the willow, and the poplar is an important wood in pulp and other industries. Like most leaf-beetles, this species has an enormous potential reproductive capacity, and should they appear on poplars in this State in such swarms as they did in Manitoba in 1911 and 1912 they could do immense injury. They can be controlled by the use of arsenicals as explained under the blueberry leaf-beetle (page 104) wherever spraying or dusting is feasible.

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THE BROWN WILLOW LEAF-BEETLE, GALERUCELLA PERPLEXA FALL.

BIOLOGICAL NOTES.

TYPICAL LIFE HISTORY.

The following is cited as a typical life-history:

24 eggs deposited on July 8 hatched on July 19.
18 larvae molted to the second instar on July 23.
9 larvae molted to the third instar on July 27.
9 larvae entered soil as prepupae on August 1.
9 prepupae transformed to pupae on August 7.
2 pupae emerged as adults on August 12.
7 pupae emerged as adults on August 13.
9 larvae molted to the third instar on July 28.
2 larvae entered soil as prepupae on August 2.

2 prepupae transformed to pupae on August 7.
2 pupae emerged as adults on August 13.
6 larvae entered soil as prepupae on August 2.
6 prepupae transformed to pupae on August 7.
6 pupae emerged as adults on August 14.
1 larva entered soil as a prepupa on August 3.
1 prepupa transformed to a pupa on August 7.
1 pupa emerged as an adult on August 15.
6 larvae molted to the second instar on July 25.
2 larvae molted to the third instar on July 29.
2 larvae entered soil as prepupae on August 5.
2 prepupae transformed to pupae on August 9.
2 pupae emerged as adult on August 17.
4 larvae molted to the third instar on July 30.
1 larva entered soil as a prepupa on August 6.
1 prepupa transformed to a pupa on August 10.
1 pupa emerged as an adult on August 18.
2 larvae entered soil as prepupae on August 7.
2 prepupae transformed to pupae on August 10.
2 pupae emerged as adults on August 18.
1 larva entered soil as a prepupa on August 8.
1 prepupa transformed to a pupa on August 13.
1 pupa emerged as an adult on August 21.

SUMMARY OF REARINGS.

Length of the egg stage. A record which was kept of 123 eggs deposited July 7 and July 14 may be tabulated as follows:

2 hatched in 8 days, 22 in 10 days, 80 in 11 days, 11 in 12 days, 2 in 13 days and 6 in 14 days; average 11 (11.0) days.

Length of the first larval instar. A record which was kept of 64 larvae which hatched between July 18 and July 21 may be tabulated as follows:

40 molted to the second instar in 4 days, 8 in 5 days, 10 in 6 days and 6 in 7 days; average 5 (4.7) days.

Length of the second larval instar. A record which was kept of 58 larvae which molted to the second instar between July 22 and July 28 may be tabulated as follows:

3 molted to the third instar in 3 days after the first molt, 23 in 4 days, 24 in 5 days, and 8 in 6 days; average 5 (4.6) days.

Length of the third larval instar. A record which was kept of 49 larvae which molted to the third instar between July 25 and July 28 may be tabulated as follows:

4 entered soil in 4 days after the second molt, 30 in 5 days, 4 in 6 days, 4 in 7 days, 3 in 8 days, 1 in 9 days and 3 in 11 days; average 6 (5.8) days.

Length of the prepupal period. A record which was kept of 37 prepupae which entered soil between August 1 and August 9 may be tabulated as follows:

2 transformed to pupae in 3 days after entering soil, 4 in 4 days, 9 in 5 days and 22 in 6 days; average 5 (5.3) days.

Length of the pupal period. A record which was kept of 30 pupae which transformed between August 7 and August 14 may be tabulated as follows:

2 emerged as adults in 5 days after the pupal molt, 13 in 6 days, 7 in 7 days, 7 in 8 days and 1 in 9 days; average 7 (6.7) days.

DISTRIBUTION.

In Maine this species seems to be commoner than *decora,* and the writer has taken it at Lamoine in Hancock County, Enfield and Orono in Penobscot, and Freedom in Waldo. No instance of its occurrence outside of Maine is definitely known, but doubtless it has approximately the same range as *decora,* and many of the references to *decora* may well include this species also.

DESCRIPTION AND ACTIVITIES.

The brown willow leaf-beetle, *Galerucella perplexa* Fall is very closely related to *G. decora* Say, and both species are primarily willow feeders. The beetles or adults are very readily distinguishable from one another by the characters given in Fall's key, for these are constant and easily recognizable differences. So far as the writer is aware, eggs, larvae and pupae of *perplexa* Fall are indistinguishable from those of *decora* Say. In spite of this fact and the identity of the host plants, it is fair to consider the 2 distinct species since they are separable as adults and since they do not interbreed so far as is known.

The writer has found no indication of interbreeding in nature, even when he has found the 2 species living side by side on the same willows. Egg clusters taken in the field, obviously the result of a single period of oviposition, yielded invariably either

decora or *perplexa,* but never both, although not until after the adults has attained full coloration could the writer tell with which species he was dealing. Adults of the 2 species were never taken in copulation in the field, although pairs of *decora* or of *perplexa* were frequently captured. Neither did inter-mating occur when adults of the 2 species were confined in considerable numbers in a single jelly tumbler, although each species paired freely with its own kind. Eggs from isolated *decora* females yielded only *decora* as offspring, and from isolated *perplexa,* only *perplexa.* They are therefore very closely related but apparently distinct species.

Taken as a whole, *perplexa* appears to be intermediate between *decora* and *alni.* Occurring on the same host plant as *decora* and indistinguishable from it in the preparatory stages, it is readily distinguishable from it as an adult; and, barely distinguishable from *alni* as an imago, it is markedly different from it in the immature stages. *Perplexa* (like *decora*) is confined to willow and poplar and is unable to subsist on alder, whereas *alni* is confined to alder and unable to subsist on either willow or poplar.

The description of egg, larva and pupa given for *decora* will serve equally well for this species, for they seem to be identical. "Reversion" larvae such as were described for *decora* occur rarely in this species also. Seasonal history, habits, activities and range and preference of food plants are identical in both species. The only constant difference noticeable in the biology is that on the average *perplexa* requires a slightly longer time in all of its preparatory stages than does *decora.*

A description of the adult may be found on page 90 of this bulletin.

THE BROWN ALDER LEAF-BEETLE, GALERUCELLA ALNI FALL.

Biological Notes.

TYPICAL LIFE HISTORY.

The following is cited as a typical life-history:

19 eggs deposited on June 26 hatched on July 20.
3 larvae molted to the second instar on July 25.

1 larva molted to the third instar on July 28.
1 larva entered soil as a prepupa on August 7.
1 prepupa transformed to a pupa on August 12.
1 pupa emerged as an adult on August 20.
1 larva molted to the third instar on July 29.
1 larva entered soil as a prepupa on August 7.
1 prepupa transformed to a pupa on August 12.
1 pupa emerged as an adult on August 20.
1 larva molted to the third instar on July 30.
1 larva entered soil as a prepupa on August 7.
1 prepupa transformed to a pupa on August 12.
1 pupa emerged as an adult on August 21.
6 larvae molted to the second instar on July 26.
6 larvae molted to the third instar on July 30.
1 larva entered soil as a prepupa on August 7.
1 prepupa transformed to a pupa on August 13.
1 pupa emerged as an adult on August 21.
2 larvae entered soil as prepupae on August 8.
2 prepupae transformed to pupae on August 13.
2 pupae emerged as adults on August 23.
3 larvae died during the instar.
2 larvae molted to the second instar on July 27.
2 larvae died during the instar.
8 larvae died during the instar.

SUMMARY OF REARINGS.

Length of the egg stage. A record which was kept of 92 eggs deposited between June 2 and July 23 may be tabulated as follows:

19 hatched in 14 days, 7 in 15 days, 12 in 16 days, 8 in 17 days, 4 in 21 days, 6 in 23 days, 19 in 24 days, 4 in 25 days, 1 in 26 days, 2 in 27 days, 2 in 28 days, 3 in 29 days, 3 in 30 days, 1 in 32 days and 1 in 33 days; average 19 (18.8) days.

Length of the first larval instar. A record which was kept of 41 larvae which hatched between June 18 and August 3 may be tabulated as follows:

13 molted to the second instar in 4 days, 19 in 5 days, 4 in 6 days, and 5 in 7 days; average 5 (5.0) days.

Length of the second larval instar. A record which was kept of 35 larvae which molted to the second instar between June 25 and August 9 may be tabulated as follows:

5 molted to the third instar in 3 days after the first molt, 16 in 4 days, 13 in 5 days and 1 in 6 days; average 5 (4.5) days.

Length of the third larval instar. A record which was kept of 32 larvae which molted to the third instar between July 1 and August 14 may be tabulated as follows:

1 entered soil in 3 days after the pupal molt, 12 in 4 days, 3 in 5 days, 6 in 6 days, 6 in 7 days and 4 in 8 days; average 6 (5.5) days.

Length of the prepupal period. A record which was kept of 28 prepupae which entered soil between July 7 and August 19 may be tabulated as follows:

2 transformed to pupae in 3 days after entering soil, 13 in 4 days, 10 in 5 days, 2 in 6 days and 1 in 9 days; average 5 (4.6) days.

Length of the pupal period. A record which was kept of 26 pupae which transformed between July 13 and August 23 may be tabulated as follows:

3 emerged as adults in 7 days after the pupal molt, 12 in 8 days, 10 in 9 days, and 1 in 11 days; average 8 (8.3) days.

SEASONAL HISTORY IN MAINE.

This species lives over the winter in the adult stage, and remains in hibernation until late in May. They begin at once to feed, pair and oviposit, and the writer has taken eggs in the field on May 30. Egg deposition may continue through July, the latest date on which eggs were deposited in the laboratory being July 27. The bulk of egg laying falls in late June and early July. The first adult of the new generation which was reared in the laboratory emerged on July 24. Adults of the old generation usually die by mid-August, but one individual lived until September 14. There is only one generation each year, and the beetles do not pair until the summer following their emergence, but they do feed freely on the leaves until early fall before seeking their winter quarters.

DISTRIBUTION.

The writer has taken this species only in Lamoine (Hancock County) and Orono (Penobscot County). No records of its

occurrence outside of Maine are known, and it may be considered a decidedly rare species. Its range will probably be found to approximate that of its food plant, the speckled alder.

DESCRIPTION AND ACTIVITIES.

THE EGG.

Description. Almost spherical, sculptured like that of *vaccinii* Fall; dull brown in color; diameter about .8 mm. by .65 mm. The egg is illustrated in figure 15A.

Deposition. The manner of deposition is like that of *G. decora* Say, and as in this species the eggs are first soft and yellow, turning brown as they harden. The eggs are concealed in little clusters in rough places in the bark.

Hatching. Hatching is exactly as described under the blueberry leaf-beetle. The normal coloration after this process is attained in about 2 hours and a half.

THE LARVA.

Description of full grown larva. Except as noted below, the full grown larva is similar to that of the blueberry leaf-beetle described on page 89 of this bulletin:

A considerable difference in the setal pattern, as may best be seen by references to figure 14 B and C. Note that although the coloration approximates closely that of *decora* and *perplexa,* the anterior dorsal abdominal tubercle is not broader than the posterior as in those 2 species.

A very marked difference in the coloration, as follows: head varying in color from light to medium dark brown, usually light, ocelli black; legs usually gray or brown, the segments black tipped, or rarely entirely shining black; prothoracic and anal shields unpigmented, except for a narrow black mid-dorsal line on the prothoracic shield; spiracles black; tubercles very light gray scarcely darker than body, except the dorsal tubercles as noted later; body color grayish white; proleg white; a black mid-dorsal stripe extending from the prothorax through the 6th abdominal segment (rarely the 8th), varying in breadth, intensity and length due to the pigmentation of the mid-dorsal tubercles of the thorax and abdomen, which are never entirely pigmented; the lateral tubercles of mesothorax and metathorax edged with black; length 8 mm.

The general aspect is creamy white with light brown head and legs and a black dorsal streak which is typically narrower, fainter and shorter than in *decora.*

Description of just hatched larva. Arrangement of setae and tubercles the same, the tubercles proportionately larger and closer together; head proportionately larger; setae capitate; length 1.5 mm.

Head measurements. During the first instar the width of the head was found to vary from .40 mm. to .43 mm.; during the second instar from .55 mm. to .57 mm.; and during the third instar from .76 mm. to .83 mm.

Color changes of the larva during growth. A series of color changes comparable to those described for the blueberry leaf-beetle is equally characteristic of this species. There is moreover a very striking color change between the first and second instars, all of the tubercles being brown in the first instar and most of them unpigmented in the later instars. This feature which it shares with *decora* and *perplexa* is peculiar to these 3 species, so far as our data shows.

Color description of the instars. Early in the first instar, the head, legs and prothoracic and anal shields are shining black or rarely dark shining brown; all of the tubercles are very dark brown; the body is grayish white. Later in the instar the general aspect is much lighter. In the second and third instars the tubercles are uncolored except for the dorsal tubercles which are black. The black dorsal streak thus formed is continuous early in the instar, and more broken later when the tubercles are more widely separated.

Molting and coloration. The process of molting is exactly the same as that described for the blueberry leaf-beetle. Both molts are alike, and the normal coloration after each molt is attained in about 2 hours.

Feeding habits. The larvae feed only on the leaves of their host plant (alder). They do not exactly skeletonize the leaves but eat numerous small holes completely through the tissues, these perforations occurring irregularly over the whole surface of the leaf. Customarily the larvae are to be found only on the under side of the leaf, and usually only one per leaf. They can be induced to eat blueberry in the laboratory; they do not skeletonize the leaves but eat chunks out of it as they do on alder, so that the work bears no resemblance to that of the blueberry leaf-beetle.

THE PREPUPA.

The prepupal cell is formed as in the case of the blueberry leaf-beetle. The prepupa becomes strongly arcuate. The head and legs remain brown and the spiracles black, but the body becomes almost pure creamy yellow, the black pigment of the tubercles disappearing almost if not entirely.

THE PUPA.

Description of just formed pupa. Coloration similar to that described for *vaccinii* (page 100), except that typically it is much lighter yellow; setal pattern similar except for the setae of the prothorax shown in figure 14G; length about 4.5 mm.; figures 15 F and G represent the pupa of this species.

Color cycle of pupa. As the pupa grows older certain color changes occur correlated with the progress of internal metamorphosis. Usually on the 3rd day light brown pigment appears in the eyes, which are dark brown on the 4th day and black on the 5th, the red brown pigment of the mandibles appearing at the same time. On the 7th day or 48 hours before the emergence of the adult the wings are light gray, and dark gray or black on the 8th day or 24 hours before.

Description of pupa ready to transform. The coloration is similar to that described for the blueberry leaf-beetle.

THE ADULT.

Description. See page 89 of this bulletin.

Emergence and coloration. The emergence of the adult is exactly like the process described for the blueberry leaf-beetle. More than 24 hours are required for the hardening of the cuticula and the development of the color pattern, and the newly emerged beetle usually remains at least 2 days in the pupal cell.

Feeding habits. The adults feed on the leaves of the alder as do the larvae, and the work of the two stages is almost indistinguishable. The adult beetles will not eat blueberry. They feed in the fall before entering winter quarters and in the spring after they come out from hibernation, both before and after copulation and oviposition.

Breeding habits. Copulation usually takes place several times each season. The largest number of eggs deposited by a single female was 108. This beetle mated on June 22, and deposited eggs between June 24 and July 20, dying on August 2. The eggs are deposited in clusters of from 2 to 25, usually about 12.

Food Plants.

Natural food plants. In nature the writer has taken these beetles only on the speckled alder, *Alnus incana* (L.) Moench.

Food plant tests. Larvae and adults were tested with 22 species of plants representing many different families. Both larvae and adults ate readily the smooth alder, *A. rugosa* (Du-Roi) Spreng, and they will doubtless eat any member of the genus *Alnus* (Tourn) Hill. With one exception all other tests were negative, and it seems certain that this species is confined to alder.

The larvae eat very indifferently the leaves of the low sweet blueberry, *Vaccinium pennsylvanicum* Lam. It is very doubtful, however, if they would be able to subsist very long on this plant. They refuse all other species of blueberry, and the adults will not eat even this species.

The following food plants, refused both by larvae and adults of the brown alder leaf beetle are of special significance as they are the primary hosts of other species of Galerucella: azalea, elm, golden-rod, meadow-sweet, red cherry, sheep laurel, yellow pond lily and willow (and poplar).

Gray birch, *Betula populifolia* Marsh, and hazelnut, *Corylus americana* Walt., both closely related botanically to alder, were refused both by larvae and adult.

Economic Importance.

An estimate of the importance of the alder leaf-beetle will depend upon one's valuation of the alder. Those who regard alders as a distinctive and pleasant feature of the landscape—admiring especially, perhaps, the purple tone of their branches during the winter and early spring—will regret any attack on this beauty. Those who look to the alder as an addition to their wood supply every few years will not care to have this item interfered

with. Those who consider alders a weed about the place will not feel antagonistic toward an insect attacking them.

Although the enormous reproductive capacity of this insect makes its abundance seem possible at any season when not held under natural control, since it is apparently restricted to the alder, this beetle may safely be considered as in a different class from the alder flea-beetle, which must be regarded as a potential menace to other trees because it is equally able to live on willow or poplar. But in view of the great destructiveness of some species of *Galerucella,* it is important that we should know accurately the biology and the range of food plants of all members of this genus, the more so since in many cases a form of great economic importance is very closely related to a species of much less importance, as is *decora* to *alni, vaccinii* to *spiraeae,* and *cavicollis* to *kalmiae* and *rufosanguinea.*

THE MEADOW-SWEET LEAF-BEETLE, GALERUCELLA SPIRAEAE FALL.

BIOLOGICAL NOTES.

TYPICAL LIFE HISTORY.

The following is cited as a typical life history:

9 eggs deposited June 10 hatched on June 26.
1 larva molted to the second instar on June 30.
1 larva molted to the third instar on July 6.
1 larva entered soil as a prepupa on July 11.
1 prepupa transformed to a pupa on July 16.
1 pupa emerged as an adult on July 23.
2 larvae molted to the second instar on July 1.
2 larvae molted to the third instar on July 6.
2 larvae entered soil as prepupae on July 11.
1 prepupa transformed to a pupa on July 16.
1 pupa emerged as an adult on July 24.
1 prepupa transformed to a pupa on July 16.
1 pupa emerged as an adult on July 25.
6 larvae molted to the second instar on July 2.
6 larvae molted to the third instar on July 7.
2 larvae entered soil as prepupae on July 11.
2 prepupae transformed to pupae on July 17.
2 pupae emerged as adults on July 25.
4 larvae entered the soil as prepupae on July 12.

4 prepupae transformed to pupae on July 18.
4 pupae emerged as adults on July 25.

SUMMARY OF REARINGS.

Length of the egg stage. A record which was kept of 25 eggs deposited between May 24 and June 17 may be tabulated as follows:

3 hatched in 13 days, 13 in 16 days, 2 in 17 days, and 7 in 22 days; average 17 (17.4) days.

Length of the first larval instar. A record which was kept of 55 larvae which hatched between June 9 and July 25 may be tabulated as follows:

9 molted to the second instar in 4 days, 19 in 5 days, and 27 in 6 days; average 5 (5.3) days.

Length of the second larval instar. A record which was kept of 33 larvae which molted to the second instar between June 15 and July 28 may be tabulated as follows:

3 molted to the third instar in 3 days after the first molt, 12 in 4 days, 13 in 5 days and 5 in 6 days; average 5 (4.6) days.

Length of the third larval instar. A record which was kept of 27 larvae which molted to the third instar between June 18 and July 10 may be tabulated as follows:

2 entered soil in 4 days after the second molt, 11 in 5 days, 10 in 6 days and 4 in 7 days; average 6 (5.7) days.

Length of the prepupal period. A record which was kept of 33 prepupae which entered soil between July 11 and July 29 may be tabulated as follows:

5 transformed to pupae in 4 days after entering soil, 10 in 5 days, 4 in 6 days, 12 in 7 days and 2 in 8 days; average 6 (6.1) days.

Length of the pupal instar. A record which was kept of 29 pupae which transformed between July 16 and August 3 may be tabulated as follows:

9 emerged as adults in 6 days after the pupal molt, 6 in 7 days, 4 in 8 days and 10 in 10 days; average 8 (7.8) days.

SEASONAL HISTORY IN MAINE.

The meadow-sweet leaf-beetle passes the winter in the adult or beetle condition, hidden away in sheltered places at the base of the bushes. They appear about May 20 each spring, and begin to feed, pair and oviposit at once. Oviposition lasts about 2 months, the extreme dates of recorded egg deposition being May 23 and July 25. An adult of the new generation was reared in the laboratory as early as July 5. August 2 is the latest date for the observed survival of a beetle of the old generation. As is the case of all species of the *decora* group, there is only one generation each year, and the beetles do not mate until the summer following their emergence but they do feed freely until into the fall before entering hibernation.

DISTRIBUTION.

The writer has taken this species in Orono, Lamoine and Monmouth in Maine, in Pittsfield, Massachusetts and in Middletown, Connecticut. Doctor Fall has taken it in Maine, New Hampshire and Massachusetts, and has specimens from Montreal, Canada. It is likely that its range approximates that of its host plant, meadow-sweet.

DESCRIPTION AND ACTIVITIES.

THE EGG.

Description. Almost spherical, sculptured like that of *vaccinii* Fall; dull brown in color; diameter about .8 mm. by .6 mm.

Deposition. The eggs are deposited at the base of the stem of the food plant, and are so well concealed it is hard to find them in the field. When first deposited they are soft and yellow, but soon harden turning brown in the meanwhile. They are of the same size as *vaccinii* eggs, but brown instead of yellow. They turn gray 24 hours before hatching.

THE LARVA.

Description of full grown larva. Except as noted below, the full grown larva is similar to that of the blueberry leaf-beetle described on page 95 of this bulletin:

A difference in the setal pattern as may best be seen by reference to figure 14D; the ventral setal pattern is similar to that of *vaccinii,* figure 13B.

The coloration is practically identical; length 6.5-7 mm.

Description of just-hatched larva. Arrangement of setae and tubercles the same; the tubercles proportionately larger and closer together; head proportionately larger; setae capitate; length 1.5 mm.

Head measurements. During the first instar the width of the head was found to vary from .38 mm. to .40 mm.; during the second instar from .49 mm. to .50 mm.; and during the third instar from .68 mm. to .71 mm.

Color changes of larva during growth. A series of color changes comparable to that described for the blueberry leaf-beetle is equally characteristic of this species.

Color description of the instars. In the first instar the head is shining black, the legs and shields dark brown, and the tubercles lighter brown; anal proleg yellowish, body color greenish yellow; general aspect dark early in the instar, much lighter later. In the second and third instars the coloration is similar but the head and legs are lighter in color.

Molting and coloration. The process of molting is exactly the same as that described for the blueberry leaf-beetle. Both molts are alike, and the normal coloration after each molt is acquired in about 2 hours.

Feeding habits. The larvae feed only on the leaves of their host plant of which they are fine skeletonizers. They live exclusively on the lower surface of the leaves, and are usually solitary. They eat the parenchyma and both epidermises, leaving a network of the finer veins.

THE PREPUPA.

The prepupal cell is formed as in the case of the blueberry leaf-beetle. The prepupa becomes progressively very yellow and the cuticular pigments duller; the body becomes strongly arcuate.

THE PUPA.

Description of just formed pupa. Coloration similar to that described for *vaccinii* (page 100); setal pattern similar except for

the setae of the prothorax shown in figure 14H; length about 4.5 mm.-5 mm.

Color cycle of pupa. The color cycle of the pupa is similar to that described for the blueberry leaf-beetle.

Description of pupa ready to transform. The coloration is similar to that described for the blueberry leaf-beetle.

THE ADULT.

Description. See page 89 of this bulletin.

Emergence and coloration. The emergence of the adult is exactly like the process described for the blueberry leaf-beetle. About 24 hours are required for the hardening of the cuticula and the development of the color pattern.

Feeding habits. The adults skeletonize the leaves as do the larvae, but more coarsely. They feed in the fall before entering winter quarters and in the spring after they come out from hibernation, both before and after copulation and ovipostion.

Breeding habits. Copulation usually takes place several times each season. The largest number of eggs deposited by a single female under observation was 361. This beetle mated on May 22 and deposited eggs between May 23 and July 7, dying on July 7.

FOOD PLANTS.

Natural food plants. In nature the writer has taken these beetles only on the meadow-sweet, *Spiraea latifolia* Borkh.

Food plant tests. Larvae and adults were tested with 31 species of plants representing a wide range of families. In addition to meadow-sweet, both larvae and adults ate readily the several species of cultivated spiraeas which were offered them. The writer does not know the exact scientific name of any of these species, but all fall under the *Chamaedryon* section of *Spiraea*. Both larvae and adults refused to eat hardhack, *S. tomentosa* L, a species which like *latifolia* Borkh, falls in the *Spiraea* section, but in the hardhack the leaves are very woolly, which probably accounts for the refusal, and the writer suspects that this insect will eat any non-tomentose species of *Spiraea* (Tourn) L., the common meadow-sweet of eastern North America being the preferred host plant.

All other food plant tests were negative. The following plants refused by the meadow-sweet leaf-beetle are primary host plants of other species of *Galerucella* which gives them special significance: alder, azalea, blueberry, elm, golden-rod, red cherry, sheep laurel, willow and yellow pond-lily.

Economic Importance.

The meadow-sweet leaf-beetle is not an insect of serious economic importance, but since it is closely related to the blueberry leaf-beetle, a detailed knowledge of its biology seemed desirable. The meadow-sweet belongs to the natural plant family Rosaceae which includes many forms of great agricultural value, but food plant tests indicate plainly that fortunately the meadow-sweet leaf-beetle is confined to the genus *Spiraea* which is not of commercial importance save in ornamental plantings. Apparently this beetle can thrive on any of the smooth leaved species of *Spiraea* common in cultivation; should it ever appear in numbers, it could be controlled by the methods described for the blueberry leaf-beetle.

THE LAUREL LEAF-BEETLE, GALERUCELLA KALMIAE FALL.

Biological Notes.

typical life history.

The following is cited as a typical life-history:

6 eggs deposited on June 8 hatched on June 26.
6 larvae molted to the second instar on June 29.
2 larvae molted to the third instar on July 1.
2 larvae entered soil as prepupae on July 7.
2 prepupae transformed to pupae on July 14.
2 pupae emerged as adults on July 21.
1 larva molted to the third instar on July 2.
1 larva entered soil as a prepupa on July 8.
1 prepupa transformed to a pupa on July 15.
1 pupa emerged as an adult on July 23.
3 larvae molted to the third instar on July 3.
3 larvae entered soil as prepupae on July 9.
1 prepupa transformed to a pupa on July 16.

1 pupa emerged as an adult on July 25.
1 prepupa transformed to a pupa on July 17.
1 pupa emerged as an adult on July 26.
1 prepupa transformed to a pupa on July 18.
1 pupa emerged as an adult on July 26.

SUMMARY OF REARINGS.

Length of the egg stage. A record which was kept of 84 eggs deposited between May 24 and June 19 may be tabulated as follows:

16 hatched in 12 days, 4 in 13 days, 1 in 14 days, 2 in 15 days, 15 in 16 days, 11 in 17 days, 8 in 18 days, 1 in 19 days, 3 in 21 days, 6 in 23 days, 14 in 24 days, 1 in 26 days and 2 in 28 days; average 18 (17.8) days.

Length of the first larval instar. A record which was kept of 43 larvae which hatched between June 5 and July 2 may be tabulated as follows:

8 molted to the second instar in 3 days, 2 in 4 days, 21 in 5 days, 9 in 6 days, 2 in 7 days and 1 in 8 days; average 5 (4.9) days.

Length of the second larval instar. A record which was kept of 39 larvae which molted to the second instar between June 10 and July 9 may be tabulated as follows:

2 molted to the third instar in 2 days after the first molt, 2 in 3 days, 13 in 4 days, 11 in 5 days, 10 in 6 days and 1 in 7 days; average 5 (4.9) days.

Length of the third larval instar. A record which was kept of 25 larvae which molted to the third instar between June 17 and July 13 may be tabulated as follows:

4 entered soil in 4 days after the second molt, 14 in 5 days, 1 in 6 days, 3 in 7 days and 3 in 8 days; average 5 (5.4) days.

Length of the prepupal period. A record which was kept of 13 prepupae which entered soil between June 25 and July 16 may be tabulated as follows:

8 transformed to pupae in 4 days after entering soil, 2 in 7 days and 3 in 8 days; average 7 (6.6) days.

Length of the pupal instar. A record which was kept of 30 pupae which transformed between June 27 and July 23 may be tabulated as follows:

3 emerged as adults in 7 days after the pupal molt, 17 in 8 days, 7 in 9 days, 1 in 10 days, 1 in 11 days and 1 in 12 days; average 8 (8.4) days.

SEASONAL HISTORY IN MAINE.

The 5 species of *Galerucella* thus far discussed from the biological standpoint are all members of the *decora* group; the laurel leaf-beetle and the 2 following species are members of the *cavicollis* group, but the life-history of all members of both groups is substantially the same.

The laurel leaf-beetle passes the winter in the adult stage hidden away in the debris at the base of the bushes, coming out from hibernation early in May. The writer has taken them in the field as early as May 9 even in Maine; this is an earlier appearance than the related species make, but is probably correlated with the evergreen nature of the host plant. By the 15th or 20th of May, the beetles are common and pairing. The extreme dates recorded for oviposition are May 21 and July 21. The first adult of the new generation to be bred through in the laboratory emerged on July 6; the latest date for the survival of one of the beetles of the old generation is September 1.

There is only one generation each year in members of the *cavicollis* group as in the species of the *decora* group, for the beetles do not mate until the summer following their emergence, but they do feed freely until well into the fall before entering their winter quarters.

DISTRIBUTION.

The writer has taken this species in Kineo, Lamoine and Orono in Maine. Doctor Fall has taken it in various localities in Maine, New Hampshire and Massachusetts. The range of this species will perhaps be found to approximate that of its preferred food plant, the sheep laurel. Probably most if not all records of *rufosanguinea* north of Massachusetts should properly be referred to this species for *rufosanguinea* appears to be confined to the purple azalea which does not extend north of Massachusetts.

DESCRIPTION AND ACTIVITIES.

THE EGG.

Description. Almost spherical, sculptured like that of *vaccinii;* yellow or orange, typically more orange than that of *vaccinii;* diameter about .8 mm. by .6 mm.

Deposition. The eggs are deposited at the base of the laurel bushes, but are well concealed. They are soft when first deposited, but like those of *vaccinii,* remain yellow instead of turning brown after they harden. They turn gray 24 hours before hatching.

Hatching. The process of hatching and the coloration after hatching is exactly as described for the blueberry leaf-beetle.

THE LARVA.

Description of full grown larva. Except as noted below, the full grown larva is similar to that of the blueberry leaf-beetle described on page 93 of this bulletin:

A considerable difference in the setal pattern as may best be seen by reference to figures 14 B and E.

A slight difference in coloration as noted below; length 7.-7.5 mm.

Description of just-hatched larva. Arrangement of setae and tubercles the same; the tubercles proportionately larger and closer together; head proportionately larger; setae capitate; length 1.5 mm.

Head measurements. During the first instar the width of the head was found to vary from .40 mm. to .44 mm.; during the second instar from .60 mm. to .61 mm.; and during the third instar from .79 mm. to .81 mm.

Color changes of larva during growth. A series of color changes comparable to that described for the blueberry leaf-beetle is equally characteristic of this species.

Color description of the instars. In the first instar the head is shining black, the prothoracic and anal shields dark brown, the legs dark brown or black; tubercles brown; body color honey-yellow before and greenish yellow after feeding; spiracles black; early in the instar the general aspect is dark and late in the instar the general aspect is light.

The coloration is similar in the second and third instars, but the cuticular pigments are lighter; the shields are little if any darker than the tubercles, the legs are prevailingly gray or brown, black-tipped; and the head is usually light brown, more or less marked with darker brown.

Molting and coloration. The process of molting is exactly the same as was described for the blueberry leaf-beetle. Both molts are alike. The normal coloration after each molt is attained in about 4 hours.

Feeding habits. The larvae feed on the underside of the leaves of their food plant, eating the lower epidermis and mesophyll, and leaving the upper epidermis which turns brown, so that the bushes look as if they had been scorched by fire. They never eat holes through the leaf and they do not skeletonize. The very young larvae are to be found in the revolute margins of the unfolding leaves.

THE PREPUPA.

The prepupal cell is formed as in the case of the blueberry leaf-beetle. The prepupa becomes strongly arcuate; it also becomes progressively more yellowish and the cuticular pigments, duller.

THE PUPA.

Description of just formed pupa. Coloration similar to that described for *vaccinii* (page 100); setal pattern similar except for the setae of the prothorax shown in figure 21; length about 5 mm.-5.5 mm.

Color cycle of pupa. As the pupa grows older certain color changes appear correlated with the progress of the internal metamorphosis. The eyes typically become light brown on the 3rd day, brown on the 4th, dark brown on the 5th and black on the 6th, the mandibles becoming red brown on the same day; the wings are gray on the 7th, or 24 hours before emergence.

Description of pupa ready to transform. The coloration is similar to that of blueberry leaf-beetle.

THE ADULT.

Description. See page 87 of this bulletin.

Emergence and coloration. The emergence of the adult is exactly like that of the blueberry leaf-beetle. About 24 hours are required for the hardening of the cuticula and the development of the color pattern.

Feeding habits. The adults feed freely on either surface of the leaves, eat holes through the leaves so that their work is easily recognizable from that of the larvae. They feed both in the fall before entering winter quarters and in the spring after they have come out from hibernation, both before and after mating and oviposition.

Breeding habits. Copulation usually takes place several times a season. The greatest number of eggs deposited by a single female under observation was 326; this beetle mated on May 20 and deposited eggs between May 21 and July 7, dying on September 1. The largest number deposited by a single female in 24 hours was 18.

FOOD PLANTS.

Natural food plants. In nature the writer has taken these beetles only on sheep laurel, *Kalmia angustifolia* L.

Food plant tests. Larvae and adults were tested with 30 species of plants. In addition to sheep laurel, both larvae and adults ate readily mountain laurel, *Kalmia latifolia* L.

All other tests were negative. The following plants refused by the laurel leaf-beetle represent primary host plants of other species of *Galerucella:* alder, azalea, blueberry, elm, golden-rod, meadow-sweet, red cherry and yellow pond-lily.

The following are the members of the natural plant family Ericaceae which were tested with negative results: *Ledum groenlandicum* Oeder (Labrador tea), *Rhodora nudiflorum* (L.) Torr. (Purple azalea), *R. canadense* (L.) BSP (Rhodora), *R. maximum* L. (great laurel), *Andromeda glaucophylla* Link (bog rosemary), *Chamaedaphne calyculata* (L.) Moench (cassandra), *Gaylussacia baccata* (Wang?) C? Koch (black huckleberry), *Vaccinium pennsylvanicum* Lam. (low sweet blueberry), *V. canadense* Kalm. (sour-top blueberry), *V. corymbosum* L. (high blueberry) and *V. Macrocarpon* Ait. (American cranberry).

Economic Importance.

The laurel leaf-beetle is closely related to the destructive cherry leaf-beetle, but fortunately is apparently confined in its range of food plants to the genus *Kalmia*. This genus includes shrubs that from the commercial standpoint are of importance only in ornamental plantings. Should these beetles ever prove troublesome in a nursery or on an estate they could be controlled by an arsenical spray, as is described for the blueberry leaf-beetle.

THE CHERRY LEAF-BEETLE, GALERUCELLA CAVICOLLIS LECONTE.

The cherry leaf-beetle is the most injurious of our native species of Galerucella, but since it has already been treated extensively (see especially Geneva bulletin 444, U. S. Department bulletin 352, and Jour. ag. res. v. 5:943-999) in the economic literature, only a few notes are added here.

The writer has taken this species in Maine at Freedom, Lamoine and Orono, and in Connecticut at New Haven, in all cases on the wild red cherry, *Prunus pennsylvanica* L.F., which is unquestionably the primary host plant. Mr. Davis has reported them as feeding in nature on the wild black cherry, *Prunus serotina* Ehrh. at Rock City, N. Y. (Jour. N. Y. Ent. Soc. v. 24:165-166), and although the writer has not taken *cavicollis* on black cherry, he has found that both larvae and adults eat it in the laboratory almost as readily as they will red cherry, and he has been able to rear adults from larvae which fed only upon black cherry from the time of hatching to the prepupal period.

Food plant tests were negative for both larvae and adults for the following plants which are the primary hosts of other species of *Galerucella:* alder, blueberry (low sweet), elm, goldenrod, meadow-sweet, sheep laurel, willow and yellow pond-lily.

THE AZALEA LEAF-BEETLE, GALERUCELLA RUFOSANGUINEA SAY.

The writer has not taken this species in Maine, but it is mentioned here since it has been recorded from Canada. Probably records of *rufosanguinea* north of Massachusetts are in most

cases referable to *kalmiae* Fall described as a new species in this bulletin. It is not to be expected that this species will be taken in Maine for its primary food plant is probably the purple azalea, *Rhododendron nudiflorum* (L.) Torr., which does not range north of Massachusetts. Van Dyke has recorded it on the flame-colored azalea, *R. calendulaceum* (Michx.) Torr. in North Carolina (Jour. ec. ent. v. 11:431, qualified by note v. 12:219).

The writer has taken this species in Middletown, Connecticut on purple azalea. The life history is that typical of the *cavicollis* group; they hibernate as adults, and there is only one generation each year.

THE POND-LILY LEAF-BEETLE, GALERUCELLA NYMPHAEAE L.

The pond-lily leaf-beetle is widely distributed through the northern parts of Europe and North America, and has recently been recorded by Blatchley as far south as Florida (Can. ent. v. 51:65). The writer has taken it commonly both in Maine (Orono) and in Connecticut (Middletown and Hadlyme).

The preparatory stages have been described by MacGillivray (N. Y. State Museum Bul. 68:325-326). The writer has not made extended observations on this species; certainly they hibernate as adults, and there is probably only one generation each year. In Middletown the beetles may remain active in the fall at least until mid-November.

The primary food plant is doubtless the yellow pond-lily, *Nymphaea advena* Ait. Less frequently they attack the white water-lily, *Castalia odorata* (Ait.) Woodville and Wood. Chittenden (U. S. Bur. Ent. Bul. 54 p. 58) adds *Brasenia* and *Sagittaria* to the list of natural food plants.

Food plant tests with the larvae as subjects were negative for the following plants which are primary hosts of other species of *Galerucella:* alder, azalea, blueberry, elm, golden-rod, ragweed, red cherry, sheep laurel and willow. The adults were negative with all of the above except elm and willow which they ate quite freely. Chittenden (l.c.) has recorded the adults as injurious to willows and beans.

Chittenden (l.c.) quotes the report of Quilter (1887. The entomologist v. 20:178-181) of the larvae on *Polygonum amphib-*

ium as of doubtful reference to this species. However this past summer (1923) the writer took specimens at Hadlyme, Connecticut on *Polygonum hydropiperoides* Michx. in all stages that were indistinguishable from the typical *nymphaeae* growing on *Nymphaea advena* Ait. close by. Those collected on the water-lily either as larvae or adults ate the smartweed without hesitation in the laboratory and vice versa. They ate equally freely *P. pennsylvanicum* L. and *P. persicaria* L. Larvae taken in the second instar were reared successfully to the adult stage on *P. persicaria,* and the adults ate freely all species of *Polygonum* (Tourn.) L section *Persicaria* (Tourn.) L. offered them as well as water-lily.

Packard (Guide to the study of insects, ed. 5 p. 505) wrote in 1876 "We found *Galeruca marginella* Kirby in all its stages of growth on *Myrica gale* during the middle of August in northern Maine. ....When about to transform it fastens itself by its tail to the surface of a leaf. ...."*Marginella* Kirby is now considered a synonym of *nymphaeae* L. but there is apparently a distinct "sweet gale" race for ordinary *nymphaeae* taken on pond-lily will not eat sweet gale either as larvae or adults. Doctor Patch of this Experiment Station "rediscovered" this sweet gale race in the summer of 1922 at Lake Meddybemps, Washington County, Maine. She found all stages on the sweet-gale, and very kindly sent alcoholic material to the writer, as well as living specimens of the adults. They are indistinguishable in all stages from typical *nymphaeae* save in food habits. Their preferred host is sweet gale *(Myrica Gale* L.), but they also will eat bayberry *(M. carolinensis* Mill.), and will eat but not readily yellow pond-lily. The eggs are deposited in clusters like those of *nymphaeae,* and the larva fastens itself to the leaf before transforming to the pupa stage, as does that of *nymphaeae,* a habit peculiar to this species so far as *Galerucella* is concerned.

Geoffroy (1762. Histoire abregee des insectes....t. 1:254) lists this species as "la galeruque aquatique," making it #4 of what he is proposing as the genus *Galeruca.* He states that the larvae live on *Potamogeton* and that they are often to be found submerged. There must therefore be still a third biological race for the writer has not been able to induce either adults or larvae of typical *nymphaeae* to feed on *Potamogeton.* (The species used was *P. heterophyllus* Schreb.) The larvae can stand temporary

submergence but not the long-continued submergence Geoffroy's account would seem to imply.

The need for more work on the biology of this species is evident, and it may well be that *nymphaeae* as we now know it is a composite species, and that further study will show that some of the names repressed as synonyms should be restored. Apparently the typical *nymphaeae* has for its primary host plant in this country the yellow pond-lily *(Nymphaea advena* Ait.: a closely related species *N. minima* Reichenb. occurs in Europe) but is able to thrive on several species of *Polygonum,* and in the adult stage to eat willow, elm, bean and perhaps other plants; there is in addition a biological race adapted to the sweet-gale; and perhaps still a third adapted to the pondweeds. The peculiar method of pupation is probably an adaptation to life on a lily-pad, and the parent race is probably the water-lily form.

THE ELM LEAF-BEETLE, GALERUCELLA XANTHOMELAENA SCHRANK.

This imported species, the well-known elm leaf-beetle so destructive in southern New England, has at least a foot-hold in southwestern Maine and is potentially a menace to the elms in the entire state. It has long been known in Europe as an important enemy of the elm, and is discussed by Geoffroy in 1762 (Histoire abregee des insectes....p. 253-254) as # 3 in his newly proposed genus *Galeruca.*

The life-history in Maine is not known, but in Connecticut there are probably (according to the writer's limited observations) 2 generations each year, the adults of the 2nd generation overwintering.

While perhaps some preference is shown for European elms where they are available, our native elms are attacked by larvae and adults with great zest, and seriously damaged. At least the white elm *(Ulmus americana* L.) and the red elm *(U. fulva* Michx.) may serve as hosts. For the purposes of this bulletin, the white elm has been considered the primary host in this country, and references in the preceding food plant lists simply to "elm" have referred to this species.

Food plant tests of larvae and adults were negative for the following species, primary food plants of other members of *Gal-*

crucella: azalea, blueberry, golden-rod, ragweed, sheep laurel, and yellow pond-lily.

THE SMOOTH GOLDEN-ROD LEAF-BEETLE, GALERUCELLA CRIBRATA LECONTE.

The writer has taken the smooth golden-rod leaf-beetle at Harrington and Orono in Maine, and at Middletown, Connecticut.

There is only one generation each year, the beetles hibernating as adults. The preferred food plant is some species of golden-rod, probably *Solidago nemoralis* Ait., although they seem almost equally fond of *S. juncea* Ait. These are the only species on which the writer has taken them in the field, but in the laboratory they ate readily all species of golden-rod with which they were provided *(squarrosa* Muhl., *rugosa* Mill. and *canadensis* L.) except *S. graminifolia* (L.) Salisb. which they persistently rejected. They seem therefore to be confined to the subgenus *Virgaurea* DC of the genus *Solidago* L.

Food plant tests were negative for the following species of plants which are the preferred hosts of other members of this genus: alder, blueberry, boneset, elm, meadow-sweet, red cherry, sheep laurel, willow and yellow pond-lily.

GALERUCELLA AMERICANA FABRICIUS AND G. CONFERTA LECONTE.

The writer has taken specimens of these 2 species in Middletown, Connecticut but not in Maine. All Maine *"americana"* which he has seen are referable to the preceding species, which together with *conferta* LeC, Fall has recently re-separated from *americana* Fab. The food plants of *conferta* and *americana* are not certainly known.

GALERUCELLA NOTATA SAY, THE BONESET LEAF-BEETLE.

The writer has taken the boneset leaf-beetle at Harrington, Maine and Middletown, Connecticut, in both cases on the bone-

set *(Eupatorium perfoliatum* L.). The writer does not know the seasonal history of this species.

GALERUCELLA NOTULATA SAY, THE RAGWEED LEAF-BEETLE.

The writer has taken this species in Middletown, Connecticut, but not in Maine. As the preferred host plant is the Roman wormwood, *Ambrosia artemisiaefolia* L., a common weed throughout the state, this beetle probably will eventually be found in the state. There are 2 generations each year in Connecticut, the adults of the second generation hibernating.

FIG. 13. A-C, larva of *Galerucella vaccinii* Fall; A, dorsal aspect; B, ventral aspect *(spiraeae* similar); C, lateral aspect; D-G, pupa of *G. vaccinii* Fall; D, dorsal aspect; E, ventral aspect; F, prothorax; G, last (8th) abdominal segment and anal plate; H-K, lateral aspect of larvae; H, of *G. decora* Say; I, of *G. alni* Fall; J, of *G. spiraeae* Fall; K, of *G. kalmiae* Fall.

FIG. 14. A-F, larvae; A, dorsal aspect of *G. decora* Say; B, ventral aspect of *G. decora* Say *(alni* and *kalmiae* similar); C, dorsal aspect of *G. alni* Fall; D, dorsal aspect of *G. spiraeae* Fall; E, dorsal aspect of *G. kalmiae* Fall; F-I, prothorax of pupa; F, of *G. decora* Say; G, of *G. alni* Fall; H, of *G. spiraeae* Fall; I, of *G. kalmiae* Fall.

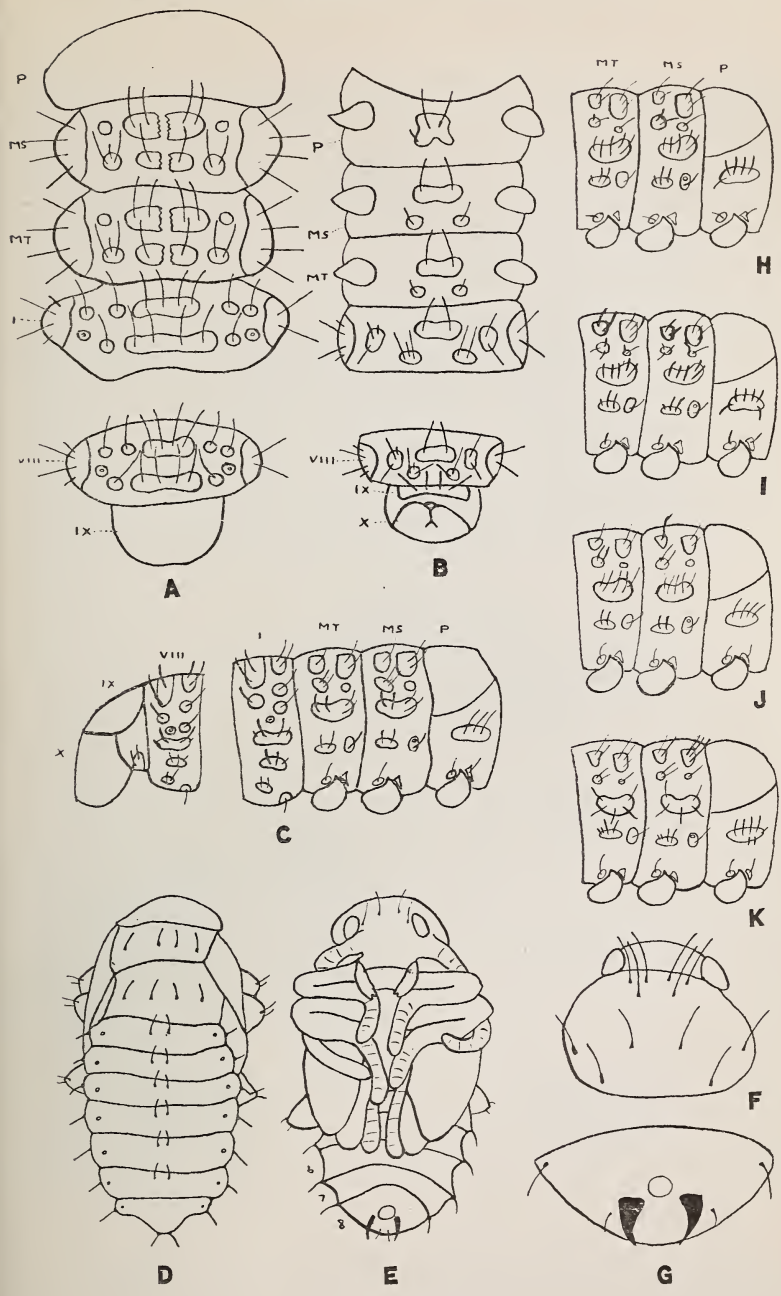

FIG. 13.—See page 138.

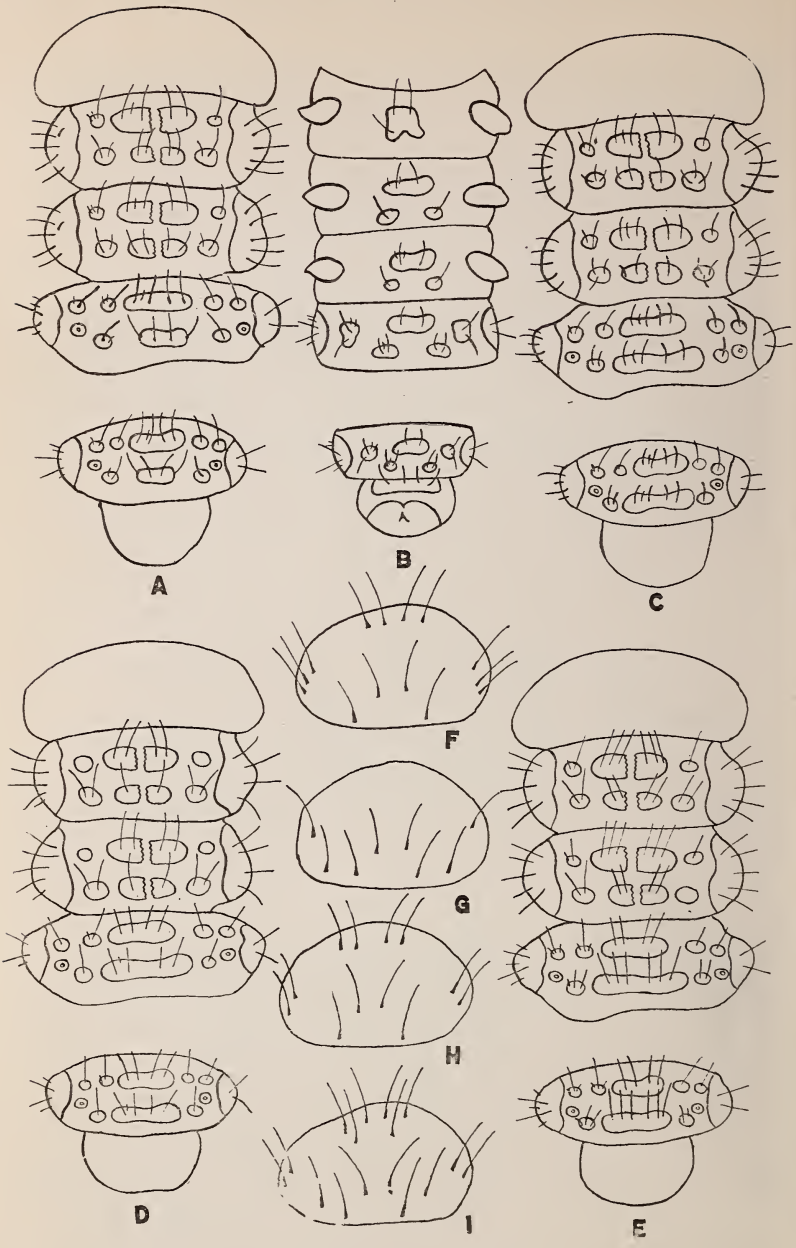

FIG. 14.—See page 138.

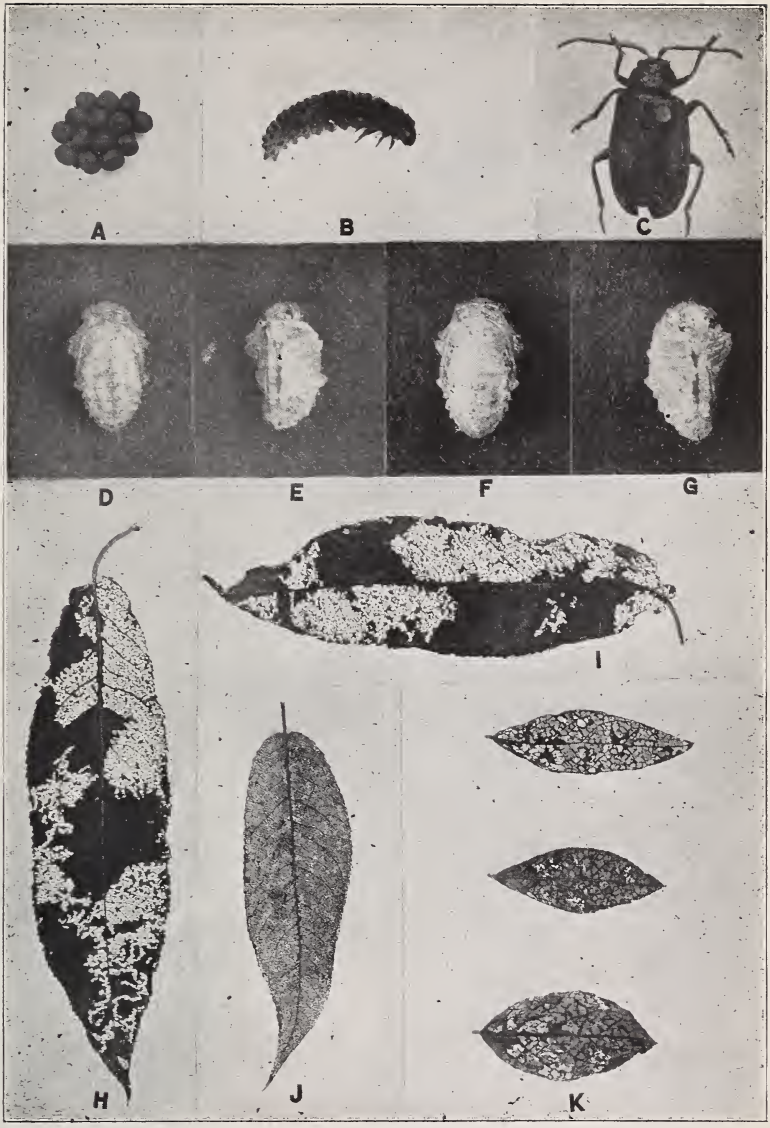

FIG. 15. A, eggs of *G. alni* Fall; B-E, *G. vaccinii* Fall; B, larva; C, adult; D, dorsal aspect of pupa; E, ventral aspect of pupa; F and G, dorsal and ventral aspects of pupa of *G. alni* Fall; H and I, work of adult *G. dcora* Say; J. work of larvae of *G. decora* Say; K, work of larvae of *G. vaccinii* Fall.